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The Newer Concepts of Meat in Nutrition

Meat...

Its Importance in the Dietary During Pregnancy and Lactation

ACCORDING to the recommendations of Macleod*, it is desirous for the pregnant and nursing woman to receive 120 grams of meat daily in addition to other sources of protein such as milk, eggs, cheese, and legumes. These foods are necessary to provide the 2.0 grams of protein per kilogram of body weight required during these periods of heightened metabolic activity.

In the face of current food scarcities and rationing programs, it may not be possible to provide this amount of meat. Yet protein deprivation need not ensue, nor need the organism be denied its full quota of essential and nonessential amino acids.

Its rich supply of the ten essential amino acids endows meat in rationing-permitted amounts with the ability to make the entire protein intake biologically adequate. Thus a mixture of meat protein and vegetable or cereal protein proves nutritionally competent since the essential amino acids are supplied by meat in sufficient amounts, providing the full meat ration is eaten weekly. In consequence, fetal growth and development are not interfered with, and the maternal organism is not unduly affected by the burden of lactation.

Meat also supplies minerals needed in greater amounts during these periods. An abundant source of iron, it aids in fetal hemoglobin formation, and contributes to the hepatic store of iron present at birth.

During lactation, when relatively large amounts of protein are lost in the milk secreted, meat aids in maintaining nitrogen equilibrium by supplying the amino acids consumed in the synthesis of albumin. Its B vitamins provide a ready source during this period of increased vitamin need.

Meat should be eaten by the gravid and lactating woman in the full permitted amounts, not only for optimum fetal development, but also to prevent catabolic destruction of maternal tissue with ensuing loss of strength and well-being.

*Macleod, J.J.R.: Macleod's Physiology in Modern Medicine 9th Ed., p. 833, The C. V. Mosby Company, St. Louis, 1941.

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American Meat Institute

CHICAGO

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OBLIQUE, ASEPTIC, END-TO-END ILEAC ANASTOMOSIS, PROCEDURE OF CHOICE IN STRANGULATING SMALL BOWEL OBSTRUCTION

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UNLESS there is a compelling contraindication, most surgeons prefer exteriorization to resection and the performance of primary anastomosis in the presence of strangulating obstruction of the small intestine. The chief compelling indication for a primary anastomotic procedure instead of exteriorization has been considered a high situation of the lesion, a situation in which intestinal fistula is definitely hazardous.

During the past 2 years, resection and primary anastomosis have become the procedure of choice at the University of Minnesota Hospitals in the management of small intestinal obstruction complicated by the presence of nonviable bowel, either from strangulation or other cause. This procedure started with an infant of 5½ weeks who recovered after resection of a gangrenous intussusceptum, a procedure performed with a background of experience with end-to-end anastomosis in dogs. In subsequent cases patients have been treated in similar fashion, until now 16 consecutive cases (15 patients) have been treated in this manner, with 2 deaths. In similar groups of cases in which older methods were used, the mortality rate has been reported at varying levels from 30 to 50 per cent (6, 15).

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TECHNIQUE OF ANASTOMOSIS

The type of procedure used in most of these cases is an oblique, aseptic, end-to-end anastomosis, a modification of that described by me 4 years ago (1), which is in turn a modification of that of Martzloff and Burget (8). One of the chief difficulties which this procedure is designed to overcome is the end-to-end union of segments of widely differing diameter without the formation of blind pockets, kinks, etc. In order to clarify presentation, the details of the procedure as now used will be presented at this point.

The mesentery is meticulously cleaned from the distended bowel proximal to the point of obstruction, a site close to the point of approach of large vessels in that mesentery being chosen (Fig. 1). A slender, crushing, anastomosis clamp is placed across the bowel, from the antimesenteric border, at an angle of about 75 degrees from the long axis of the gut. The clamp crosses the mesenteric border about 6 millimeters below the edge of the unremoved mesentery.

In order to minimize the danger of spillage of any of the content of the distended bowel during the later stages of the procedure, the contents are cautiously milked back between the fingers for 10 or 20 centimeters from the clamp, and a rubber-shod intestinal clamp is lightly applied. This clamp remains in place until the completion of the anastomosis.

Below the point of obstruction, the diameter of the bowel is usually one-third to one-half that above, and the anastomosis clamp must therefore be placed much more obliquely to attain a length of crushed tissue equal to that above. Most satisfactory stomas have been achieved by the application of the clamp *from the mesenteric border* with distortion of the bowel by Allis forceps lightly applied in such fashion that the line of crush, beginning at the mesenteric border, crosses obliquely two-thirds of the way to the antimesenteric border, then runs longitudinally down the bowel to gain the necessary length of crush before it crosses the remainder of the gut (Fig. 2, 2a). The cleaning of the mesentery and the placement of the clamp with regard to the cleaned area are accomplished as on the distended intestine.[1]

A similar clamp is placed between the bowel to be resected and each of the clamps already described, a 3 or 4 millimeter gap usually being left between clamps. The intestine is cut in the gap between each of these pairs of clamps with the actual cautery (Fig. 3).[2]

The anastomosis clamps are laid side-by-side, thus bringing the bowel ends together with one end rotated 180 degrees with respect to the other about the long axis of the gut (Fig. 4). Ideally the length of the area of crush in the 2 clamps is identical, for by this precaution the most accurate apposition of the 2 ends can be attained in making the anastomosis. The clamps are rotated away from each other, and a running basting stitch of No. 000 or No. 0000 plain catgut on an atraumatic needle is placed posteriorly, about 5 millimeters being taken in each bite, with a slightly smaller gap (4 mm.) being left between bites. Subsequent inversion occurs spontaneously at the time of withdrawal of the clamps *only if the ends of the running sutures are properly placed;* inversion of the corners with instruments, which invites contamination, may thus be avoided. Each end bite of each suture must be about 5 or 6 millimeters long and parallel with the axis of the bowel and should emerge close to the clamp (Fig. 4a).

The anastomosis clamps are now rolled together, and a similar running stitch is placed anteriorly (Fig. 5).

Tension is applied to the two ends of each of the basting sutures, the clamps are carefully loosened until the tips are spread 1 or 2 millimeters, and the clamps are cautiously and simultaneously withdrawn (Fig. 6). If the sutures have been properly placed, inversion of the cut ends of intestine will occur with no further manipulation, and clean serosal approximation will result. Tension is maintained on the basting stitches while the ends of the posterior strand are tied to the corresponding ends of the anterior strand.

With maintenance of tension on the ends of the basting stitches throughout, interrupted Halsted mattress sutures of 2½ pound test silk[3] are laid anteriorly, 20 or 30 milligrams of sulfanilamide (or sulfathiazole) is implanted on the serosa between the rows of sutures (Fig. 7), and the mattress sutures are tied *just tightly enough for snug apposition* (Fig. 8). The bowel is rolled over, and the posterior closure is similarly re-enforced, tension being continued to this point on the ends of the catgut strands. Tension on the basting sutures is gradually lessened as the stoma is broken down by inverting the bowel below the anastomosis with a thumb or two fingers and thus pushing through the stoma. The catgut basting stitch, which is circular by virtue of the knots at the ends of the suture line, is held taut by this device while inversion Halsted mattress sutures are placed at the ends. The catgut ends are cut, sulfonamide is lightly

[1] The value of this type of placement is not limited to anastomoses performed in the presence of obstruction. In the terminal ileum under normal conditions the lumen is small enough to render anastomosis without undue reduction of the lumen difficult. This type of placement of clamps with 180 degrees' rotation has proved uniformly successful under these circumstances. In other sites where bowel ends of unequal diameter are to be joined, such as in end-to-end ileocolostomy after right hemicolectomy, this type of anastomosis has also proved uniformly successful.

[2] In the experimental work the gut was transected with a knife, and the 1 millimeter portion extending beyond the clamp was thoroughly phenolized, then treated with alcohol and dried. With the acquisition of the clamps described, which are heavier than those used for most of the experimental work, it was found that the bowel could be cut flush with the anastomosis clamp without pulling through it during the procedure. It did not seem to matter in the healing whether the bowel was cut with cautery or knife.

[3] Cotton of similar strength was used in the experimental work.

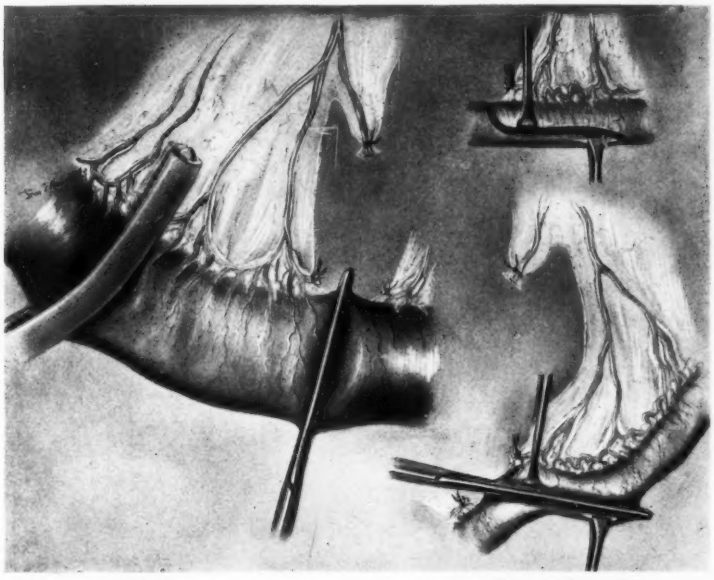

Fig. 1. Fig. 2 and 2a, above.

Fig. 1. Placement of the first anastomosis clamp on the distended bowel above the point of obstruction. The clamp crosses the bowel at an angle of 75 degrees and at the mesenteric border about 6 millimeters from the edge of the unremoved mesentery. The bowel has been milked back and a rubber-shod clamp is applied to prevent spillage.

Fig. 2. Placement of the second anastomosis clamp on the contracted bowel below the point of obstruction. The line of crush begins 6 millimeters from the unremoved mesentery, crosses obliquely ⅔ of the bowel and passes for a distance parallel with the antimesenteric border before crossing the remaining ⅓ of the bowel, a. This length of crushed tissue, equal to that in Figure 1, is obtained by distorting the bowel with Allis forceps. This clamp is placed from the mesenteric border.

placed, the silk sutures are tied, and the anastomosis thus completed.

To close the mesenteric defect, a stitch near the center of the posterior suture line is threaded on a needle and a small bite of each mesenteric edge is taken 3 centimeters from the bowel (Fig. 9), and behind it, and thus the defect in the mesentery is tied. From this point to the root of the mesentery, interrupted silk sutures are placed. Efforts to cover the suture line with omentum have been abandoned as useless. Sulfonamides have not been generally implanted into the peritoneal cavity because it has seemed that this procedure leads to excessive adhesion formation.

The clamps used in making this anastomosis differ from those of Martzloff and Burget (8) in that they are shorter and lighter (Fig. 10). With the shorter clamp one may rely less on the springiness of the instrument to crush the tissue at the tip, and the clamps may therefore be more easily removed during the anastomosis. Deep, sharp, longitudinal, matching grooves are cut on the jaws of the clamp.

The advantages of this type of anastomosis over many of those described in the literature have been discussed in a previous paper (1). Certain advantages will be emphasized at this point:

1. End-to-end anastomosis avoids the formation of the blind pouches which result from closure of both ends and side-to-side anastomosis.

2. End-to-end anastomosis necessitates but one suture line, whereas closure of the ends and side-to-side anastomosis requires three lines.

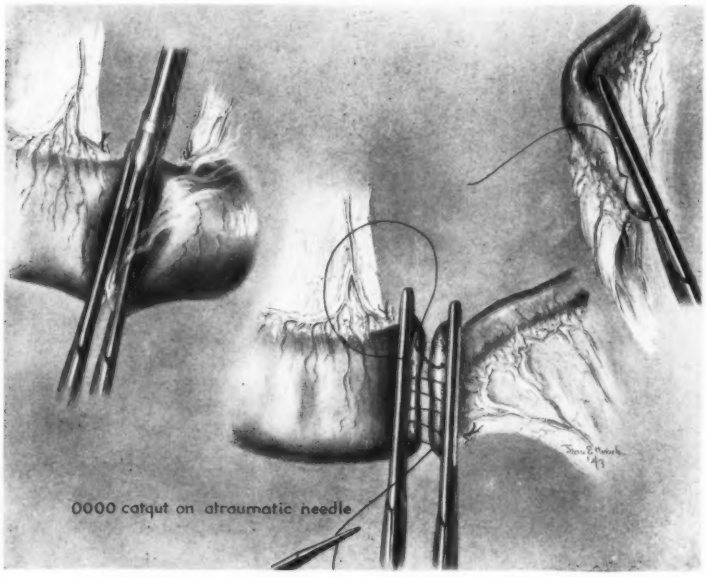

Fig. 3. Fig. 4. Fig. 4a.

Fig. 3. Cutting the bowel between the clamps described in Figure 1 and Figure 2 with the cautery. To prevent spillage additional clamps are placed between those applied for anastomosis and the specimen to be removed.

Fig. 4. Placement of the posterior running fine catgut suture. The clamps are held side-by-side, so that the bowel ends are brought together with 180 degrees' rotation of one with respect to the other. The suture is laid with the clamps rolled away from each other as shown. The bites are 5 millimeters long and the gaps between bites are 4 millimeters. a, Placement of each end bite parallel with the long axis of the gut assures good inversion later.

3. Aseptic procedure permits apposition of serosal surfaces uncontaminated with luminal contents.[1]

4. Obliquity of placement of clamps permits the best possible blood supply to the line of suture, for the vessels follow a circular course around the bowel and are not, therefore, interfered with before reaching the suture line.

5. Rotation of one segment of bowel with respect to the other minimizes angulation and therefore minimizes possibility of obstruction at the point of anastomosis, as shown in Figure 11.

6. Rotation of the bowel avoids the dangers of closure without peritoneum at the mesenteric border; in other words, by this rotation peritoneum is provided on one surface or the other completely around the line of inversion.[2]

7. This type of anastomosis avoids the danger of stenosis at any time in the postoperative period. There has been no case of dysfunction secondary to the quarter twist imposed on each end to be anastomosed.

[1] The experimental data presented illustrate this point only fairly well because of the small number of open anastomoses; but comparison of the results here reported with those of Owings and Smith, who used open procedures exclusively, furnishes abundant evidence in favor of the present procedure.

CLINICAL CASES

On 16 occasions between November 1, 1940, and March 1, 1943, nonviable segments of small intestine have been resected in the presence of small intestinal obstruction. These are consecutive cases, no patient with gangrenous bowel and obstruction having been

[2] In over 20 clinical cases and 60 experimental anastomoses, no instance of leakage at the ends of the suture line, i.e., at the mesenteric border on one side, has occurred.

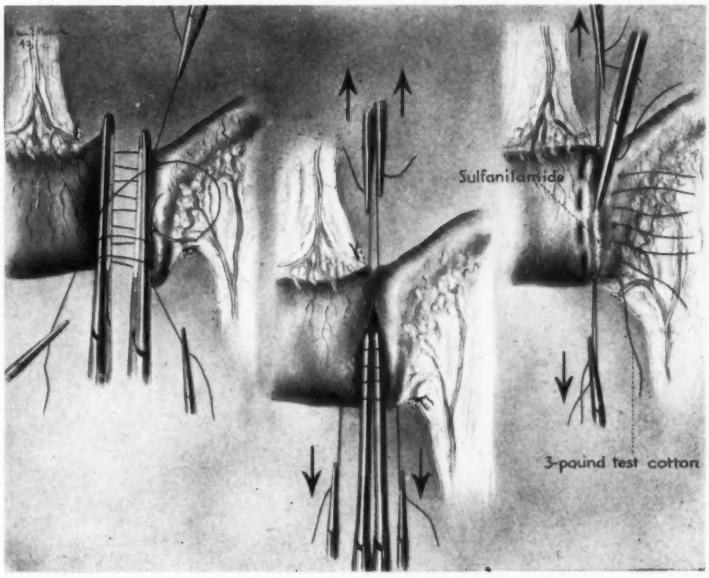

Fig. 5. Fig. 6. Fig. 7.

Fig. 5. Placement of the anterior running catgut suture. The clamps have been rolled together.

Fig. 6. Removal of clamps. Tension is applied to the two ends of each of the running sutures, the clamps are carefully loosened until the tips are spread 1 or 2 millimeters and the clamps are cautiously and simultaneously removed.

Fig. 7. Reinforcement of the suture line. The ends of the posterior running stitch have been tied to the corresponding ends of the anterior strand and tension has been maintained during placement of Halsted mattress sutures of 2½ pound silk. With the latter placed, but not tied, sulfanilamide is applied in small amounts between the serosal surfaces to be approximated by them.

denied operation. There have been 2 deaths, a patient mortality of 13.3 per cent and a case mortality of 12.5 per cent, levels no different from the mortality for intestinal obstruction as a whole at this clinic (2). The cases are summarized in Table I. More detailed summaries of 6 cases are included to illustrate special points.

Patient No. 1. U. H. 702210, male, aged 39 days, was admitted November 20, 1940, in a dehydrated state with a 60 hour history typical of intussusception. The abdomen was tympanitic and too distended to allow palpation of a mass, which could, however, be felt high on the right on rectal examination. He was transfused and given 100 cubic centimeters of 0.9 per cent sodium chloride solution before operation, and was slowly transfused during the operation. Through a right lower rectus incision, an ileocolic intussusception was identified, and the apex was milked back into the ileum, but the lesion could not be completely reduced despite considerable manipulation; efforts were terminated by occurrence of a serosal tear. The upper margin of the intussuscipiens was observed at this point to be discolored, edematous, and firmly sealed to the bowel above it. The apex could be pushed about 2½ centimeters above the ileocecal junction. The involved area was resected from this point to a site 5 centimeters above the upper margin of the intussuscipiens, and an aseptic, end-to-end anastomosis of the Martzloff-Burget type was performed with catgut used for the internal layer. About 1 gram of sulfanilamide was implanted, partly about the anastomosis and partly in the wound during catgut closure.

After operation the patient was given 100 per cent oxygen, nasal gastric suction was used, and sodium sulfathiazole was given intravenously for 36 hours. Feces were passed at 48 hours, and the temperature reached normal at 72 hours. Early feeding was cautious, but the patient improved rapidly and was dismissed 22 days after operation. He was last seen 4 months later, and seemed a normal baby at that time.

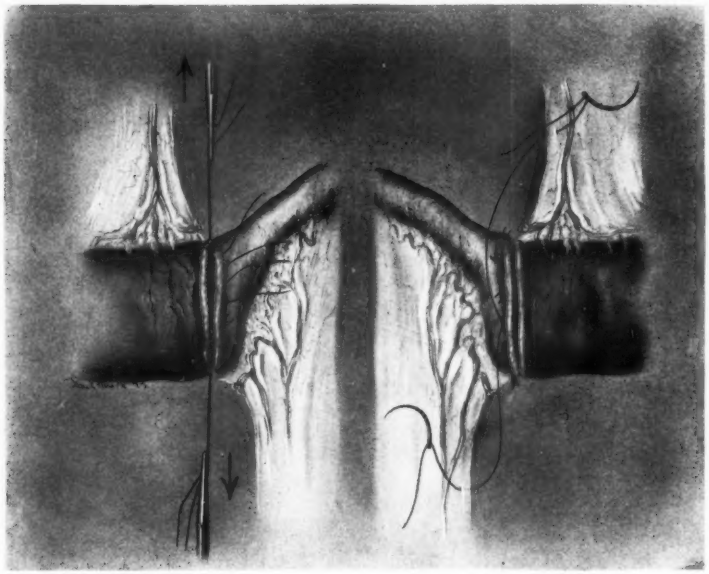

Fig. 8. Fig. 9.

Fig. 8. Tying of the Halsted mattress sutures, with maintenance of tension on catgut strands. The posterior side is treated in similar fashion.

Fig. 9. Rear view of anastomosis, showing placement of stitch to close the mesenteric defect.

The specimen presented areas of necrosis, and there was hemorrhagic infiltration of the gut wall.

Patient No. 3. U. H. 614765, female, aged 71 years, was admitted March 24, 1941, 24 hours after an old umbilical hernia had become incarcerated. Pain had become severe and constant, and vomiting was profuse. Examination showed a hernia the size of a man's head; it was very tender to touch, and the entire abdomen was tender and silent. Temperature was 98 degrees.

At operation the patient went into profound shock as soon as the transverse skin incision had been made. Following transfusion of blood and plasma, the pulse became perceptible and gradually improved. The hernia contained some colon, the cecum, the appendix, and much of the ileum. When the hernial ring was cut, the color returned to most of these viscera, but 125 centimeters of upper ileum remained black and nonmotile. This segment was resected, and oblique, aseptic, end-to-end anastomosis with implantation of sulfanilamide was performed. The hernia was repaired with silk, with great difficulty because of tension.

After operation nasal suction was used for 5 days and patient did nicely except for senile confusion and a moderate wound infection. She was followed after dismissal, and the hernia recurred 18 months later.

The specimen showed hemorrhagic infarction of the bowel.

Patient No. 5. U. H. 708767, female, aged 53 years, was admitted May 7, 1941. The patient had had many previous operations, one for adhesions. She was admitted after 48 hours of nausea and severe, colicky, abdominal pains. On admission to the hospital there were borborygmi with typical cramps. Within 12 hours she developed abdominal tenderness and rebound tenderness, and the temperature rose to 102 degrees; she was, therefore, subjected to exploration.

At operation through a left lower rectus incision, a 15 centimeter piece of ileum was found herniated beneath an adhesive band running from the dome of the bladder to an old subumbilical scar. This bowel was black, and was, therefore, resected, and a primary, oblique, aseptic, end-to-end anastomosis was performed with implantation of a total of 1¼ grams of sulfanilamide. Because of the marked distention, a catheter enterostomy was performed proximal to the suture line.[1] Because there was a drop in blood pressure late in the procedure, the wound was closed rapidly, with a running suture of catgut.[2]

[1] This is the only case in the present series in which this precaution was taken.

[2] Catgut closure has been used on 3 intestinal obstruction cases because of the poor condition of the patients (Case 1, this case, and 1 case without resection). Two of the 3 have developed hernias. In 1 case in which heavy silk was used (Case 3), because of a large hernial defect, hernia developed in the wound. In most of the remainder, whether with gangrenous bowel or not, fine silk has been used in the closure, and no wound complications have developed except in 1 case there was peritonitis (Case 12) and in another superficial infection (Case 10).

Nasal suction was discontinued in 6 days, the patient was dismissed in 15, and the enterostomy tube was withdrawn in 19 days.

Examination of the specimen showed hemorrhagic infarction.

The patient was thrown from her seat in an automobile accident on her way home, and developed immediate pain in her wound, followed by hernia formation. A year later, because of pain, this hernia was repaired. The ileum for a total of 70 centimeters above and below the old anastomosis was densely bound to the sac by scar tissue and was, therefore, removed; reanastomosis was performed as before. The patient has apparently been cured.

The pathology report on this second specimen reads:

"At approximately the midportion of this intestine there is an oblique suture line with slight thickening of the peritoneal surface and induration. The circumference of the bowel along this suture line (measured on the mucosal surface) is 8.5 centimeters. The circumference measured directly transversely is 8 centimeters. The circumference 4 centimeters above the suture line is 8.4 centimeters and also 8.4 centimeters at a point 4 centimeters below the suture line. This is an old suture line with no signs of the sutures being found. There is no evidence of leakage. On cross section an annular rim or tissue follows the line of previous sutures."[1] (Fig. 17.)

Patient No. 7. U. H. 713329, female, aged 75 years, was admitted September 29, 1941. The patient presented a 5 week history of cramps relieved by defecation. Twenty hours before admission, she developed severe abdominal pain, nausea, coffee-ground vomiting, and loose stools. She had lost 30 pounds in a month. The patient had a history of heart failure, and she had auricular fibrillation on admission. She presented signs of peritoneal irritation, and a cauliflower-like mass could be felt on pelvic examination. Temperature was 98.6 degrees, white blood count 15,000. With the possibility of peritonitis from a ruptured appendix in mind, the patient was treated conservatively for 12 hours; then return of blood through the nasal suction tube led Dr. Lyle J. Hay (then resident in surgery at the University of Minnesota Hospitals) to diagnose mesenteric vascular thrombosis and explore the abdomen.

At operation the small intestine was found gangrenous except for 10 centimeters above and 60 centimeters below. Resection with primary aseptic anastomosis was performed by the Martzloff-Burget method.

After operation the patient was rapidly digitalized, and the pulse became regular. The nasal suction was discontinued 7 days after operation, but temporary stomal obstruction thereafter marred the convalescence for some days. Diarrhea was troublesome for a short time after recovery, but the patient was dismissed 26 days after surgery. She failed all her return appointments and stopped taking her digitalis.

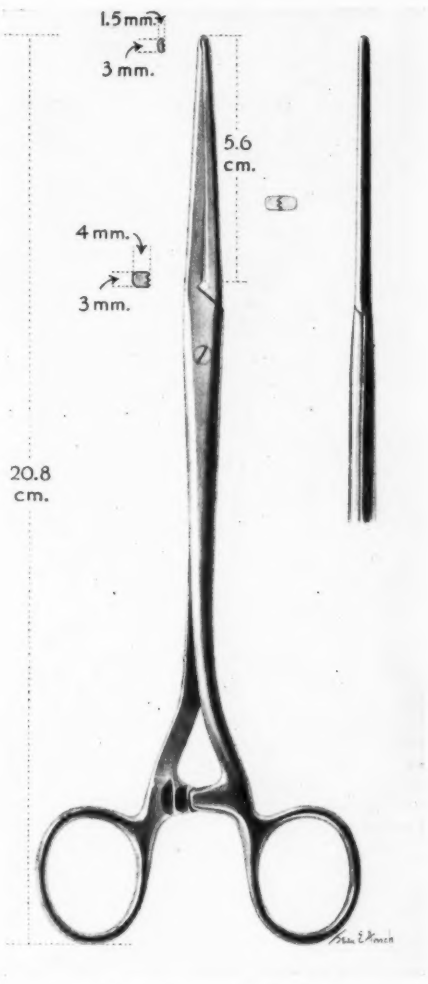

Fig. 10. The anastomosis clamps.

The specimen was 175 centimeters long after fixation, and of this, 80 centimeters was gangrenous due to mesenteric arterial thrombosis.

Patient No. 7 (second resection). This patient was readmitted October 12, 1942, after 19 hours of vomiting, cramps, and severe abdominal pain felt also in the back. With the limited length of small bowel remaining after her first resection, she had maintained excellent health, had had a voracious appetite, and had lost but 3 kilograms in a year. On

[1] These data indicate that the crushing of tissue in the anastomosis clamp does not lead to subsequent contraction of the line of suture, for the length of the area of crush at the first operation was 5 centimeters *on the serosal surface.*

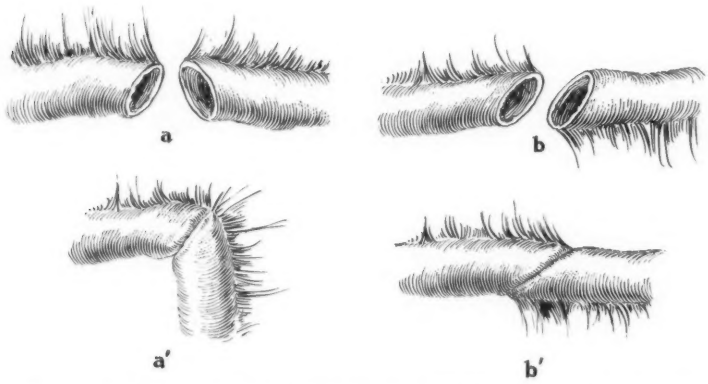

Fig. 11. a, Schematic drawing to illustrate the angulation resulting from end-to-end anastomosis of bowel cut at 45 degrees and opposed without rotation. b, The obviation of angulation accomplished by rotation of one segment with respect to the other is apparent. (Reprinted from *Surgery*, 1939, 5: 548.)

this 2d admission, the abdomen presented signs of marked peritoneal irritation, motion of the uterus was very painful, the gastric aspiration was bloody, and the electrocardiogram showed auricular fibrillation. Gangrene of the remaining small bowel was diagnosed, and the patient was rapidly (5 hours) digitalized, hydrated, and laparotomized.

At operation the remaining jejunum and ileum were found gangrenous and the abdomen contained fecal-appearing free fluid. The circulation to the cecum and duodenum seemed adequate. The ligament of Treitz and the lateral peritoneal attachment of the cecum and ascending colon were severed to allow approximation of the terminal duodenum and ascending colon, and an aseptic end-to-side anastomosis was performed, with inversion of the stump of the ileum. A total of 6 grams of sulfathiazole was implanted. Closure of the abdomen was made with steel.

On the 4th day after operation, the patient developed a right saphenous thrombophlebitis; this responded nicely to procaine lumbar sympathetic block. On the 7th day the patient developed pulmonary edema, probably from excessive fluid administration (she gained to 57.2 kilograms from the initial dehydrated level of 54.6 kilograms). Positive pressure of 8 millimeters of mercury was applied by using an anesthesia mask and a mixture of helium and oxygen; after 12 hours of such administration for 20 minutes every 4 hours, she appeared to have recovered, became mentally alert, and took cream of wheat by mouth. On the afternoon of the 8th day, she had an attack of cyanosis followed by stupor and apparent weakness of the left arm. Oxygen was administered. She did not again improve, and although the abdomen remained soft and bowel movements continued, she lost strength, had repeated attacks of cyanosis, and died 9 days after operation.

After removal of the nasal suction tube, 4 days after operation, it was observed that ingested food usually was passed in still recognizable form in less than a half hour.

The specimen removed at operation consisted of 130 centimeters of small intestine as measured in the fresh condition. Thrombi were present in both arteries and veins, and the bowel was gangrenous throughout all but 5 to 6 centimeters at each end.

Autopsy revealed a clean abdomen. The suture line anteriorly was covered by omentum. When this was removed, the suture line could be pulled apart with very little tension, and a small abscess was found between mattress sutures (a point at which there had been about 1 c.c. of spillage during the anastomosis). The mucosal surface of the line of anastomosis showed a more ragged and necrotic appearance than usual at this stage. On the wall of the colon opposite the duodenocolostomy a large, deep ulcer (5 by 7 cm.) was present. The remaining ileocolic vessels and the main trunk of the superior mesenteric vein were filled with a large fresh thrombus.[1] The mitral valves showed a subacute bacterial endocarditis with fresh vegetations, and fresh infarcts were found in the kidneys, spleen, and brain.

It would seem that this patient was lost not through any inherent defect in the anastomotic methods under discussion, but rather because the necessary resection exceeded in magnitude the limit which one can tolerate, and because of a complicating bacterial endocarditis.

Patient No. 10. U. H. 718626, female, aged 68 years, was admitted March 19, 1942. There was a 36 hour history of irreducibility of an old left lower

[1] This is the only case in the series in which there has been evidence of propagation of thrombus after resection of gangrenous bowel.

TABLE I.—SUMMARY OF CASES

Patient No.	Age	Type of obstruction	Duration	Length resected cm.	Type of anastomosis	P.O. duration of suction	Outcome	Length of hosp. stay days
1*	39 da.	Intussusception	60 hr.	8	Martzloff-Burget†	36 hr.	Well	22
2	8 yr.	Volvulus—enteric cysts	36 hr.	45	Oblique aseptic	4 days	Well	12
3*	71 yr.	Ventral hernia	48 hr.	125	Oblique aseptic	5 days	Well	21
4	46 yr.	Ventral hernia (Richter)	72 hr.	30	Oblique aseptic	6 days	Well	11
5*	53 yr.	Internal hernia	48 hr.	50	Oblique aseptic	6 days	Well	15
6	24 hr.	Vascular occlusion	2 weeks	60	Martzloff-Burget[1]	5 days	Well	13
7	75 yr.	Vascular occlusion	20 hr.	175	Martzloff-Burget[2]	7 days	Well	26
Second admission 1 yr. later:								
	76 yr.	Vascular occlusion	24 hr.	Rest of jejunum and ileum	Aseptic end-to-side duodenocolostomy	4 days	Died	9
8	11 mo.	Intussusception	40 hr.	10	Martzloff-Burget[2]	56 hr.	Well	24
9	53 yr.	Adhesions and vascular occlusion	60 hr.	34	Aseptic end-to-end ileocolostomy	6 days	Well	14
10*	68 yr.	Femoral hernia	41 hr.	50	Oblique aseptic	4 days	Well	21
11	47 yr.	Vascular occlusion	40 hr.	40	Oblique aseptic	5 days	Well	14
12*	55 yr.	Femoral hernia (Richter)	10 days	10	Oblique aseptic	6 days	Died	19
13	50 yr.	Femoral hernia	16 hr.	10	Oblique aseptic	3 days	Well	12
14	69 yr.	Vascular occlusion	5½ days	72	Aseptic end-to-end ileocolostomy	5 days	Well	9
15	57 yr.	Inguinal hernia	36 hr.	30	Aseptic end-to-end[3] ileocolostomy	5 days	Well	12

* Additional data in case summaries in the text.
† The procedure here used differs from that of Martzloff and Burget in that the internal, running stitch has always been catgut, not silk.
[1] Procedure by Dr. A. J. Kremen, fellow in surgery at the time, now in the armed forces.
[2] Procedure by Dr. Lyle Hay, fellow in surgery at the time, now in the armed forces.
[3] Procedure by Dr. Bernard G. Lannin, resident in surgery.

quadrant hernia, with abdominal cramps, lumbar pain, and vomiting. On examination the positive findings were auricular fibrillation, hypertension, a left lower quadrant hernia, 16 by 10 centimeters and bluish discoloration of the skin over the hernial protrusion. The abdomen was silent.

At operation, incision as for Bassini hernioplasty revealed the hernia to be femoral. An accessory vertical incision was made over the sac, forming a T incision. Ileum was found entering and leaving the neck of the sac, and exposure down to the sac permitted visualization through the wall of the sac of black bowel and blood black exudate. At the suggestion of Dr. R. L. Varco,[1] then resident on surgery, the bowel was cut between clamps as it entered and left the sac, and the sac itself was excised intact and without contamination of the wound with the contents. An oblique, aseptic, end-to-end anastomosis with implantation of about 100 milligrams of sulfathiazole was accomplished, and the necessarily severed inguinal ligament and the hernial defect were repaired with 5 pound test silk.

After operation the patient was rapidly digitalized, and the pulse became regular. Nasal suction was used 4 days, and a soft diet was allowed at 6 days after operation. A superficial wound infection delayed dismissal of the patient until 3 weeks after operation.

Inspection of the hernial sac showed the content to consist of 30 to 40 centimeters of gangrenous bowel and some omentum.

This method of dealing with hernias containing dead bowel and free fluid offers promise of saving a certain number of patients who have in the past been lost. It would have improved chances in Case 12 if she had come a few hours earlier.

Patient No. 12. U. H. 721428, female, aged 55 years, was admitted June 3, 1942. This patient presented a 10 day story of illness beginning with sudden severe abdominal pain, continued vomiting and cramps, and finally 6 days of conservative therapy with nasal suction and intravenous fluid administration at a local hospital. The patient was transferred to the University Hospitals on the day abdominal tenderness and fever appeared. Examination

[1] This is to be reported separately.

showed a full abdomen, rather tender to deep pressure, but the patient arrived heavily sedated. The abdomen was silent except for rare gurgles; there were no cramps. No hernias were found on careful search. Temperature was 101.2 degrees, white blood count 11,000, blood urea nitrogen 59 milligrams per cent.

Attempts to pass a Miller-Abbott tube were not successful. In doubt for a definite diagnosis, 12 hours was allowed to pass in order to establish better hydration before exploration. With the patient still clouded mentally and the temperature over 105 degrees by rectum, operation was undertaken.

The serosal surfaces were angry red in appearance; the upper ileum was distended to 6 centimeters in diameter. Fecal material was found on the serosal surfaces in the right lower quadrant, emanating from a Richter's hernia into the femoral canal. Adjacent to the ring, the bowel had perforated, leaving a fibrin-covered rent. The sac was curetted and drained extraperitoneally after it had been packed with sulfathiazole and the peritoneal defect had been closed. The involved bowel was resected and an oblique aseptic end-to-end anastomosis was made with implantation of sulfathiazole. The abdomen was closed with running No. 1 20 day chromic catgut with further sulfathiazole implantation.

The patient failed to recover consciousness. Despite good urinary outputs (1 to 2 liters) the uremia progressively deepened. Twitching of one side of the face occurred, suggesting cerebral accident. Wound infection and dehiscence to the peritoneum occurred, and the patient died 19 days after operation. For the last week she was fed by drip feedings through an inlying nasal gastric tube.

Postmortem examination showed general peritonitis, most severe in the region of the right femoral canal. The anterior line of anastomosis was found to leak midway between the mesenteric and the antimesenteric borders. Examination of the specimen implied inadequate space between the 2 lines of suture. Permission to examine the brain could not be obtained.

At the time of the performance of this anastomosis effort was being directed to the inversion of as little tissue as possible, and to the placement of the two rows of sutures very close together, a policy which has now been dropped.

THE SURVIVAL OF DOGS FOLLOWING ANASTOMOSES BY VARIOUS METHODS AFTER ILEAC OBSTRUCTION

The literature does not contain many favorable references to the application of primary anastomosis of any kind to cases of small bowel obstruction. Owings and Smith published experimental results indicating that primary, open, side-to-side anastomosis is feasible after resection of all bowel which is either distended, nonresponsive to stimuli which normally cause contraction in the dog, or which does not offer normal resistance to the passage of a suture needle. They had a considerable mortality, although it dropped to zero in the last group of dogs, in which they performed very extensive resections. They did not apply the method to clinical cases. Aside from this article, the author has not found any serious discussion in the literature of application of primary anastomosis as a procedure of choice in obstruction with nonviable or doubtfully viable bowel.

Procedure. In order to test the feasibility of primary anastomosis in the presence of obstruction in dogs, and also to evaluate one anastomotic method against another, a series of experiments was performed on 28 dogs. Adult male dogs of about 40 pounds were routinely used. About a half hour before anesthesia, ½ to ¼ grain of morphine sulfate and 1/50 grain of atropine sulfate were given subcutaneously. Following ether induction, a soft rubber intratracheal tube was placed and rendered tight by securing the mouth about the tube. A very constant level of anesthesia was maintained by use of a standard laboratory ether bottle. A left rectus incision was made, and the ileum 25 centimeters above the ileocecal junction was divided between clamps, the ends being phenolized, alcoholized, and inverted with a Parker-Kerr No. 40 commercial cotton suture (11). Closure was secured with 3 interrupted Halsted mattress sutures of the same material. The latter sutures were used to tie the inverted ends together as a precaution against intussusception, and the abdomen was closed in layers.

The dogs were returned to a room in which the temperature was held between 80 and 85 degrees F., a precaution which cut the loss from pneumonia from 50 per cent almost to zero. Following obstruction, fluid was supplied intravenously in the form of 0.9 per cent sodium chloride, 750 cubic centimeters being given twice daily.

At an interval of days after obstruction, the animals were given 0 to ¼ grain of morphine sulfate and 1/100 grain of atropine sul-

fate, and anesthetized as before with ether. Through a right rectus incision the area of obstruction was delivered, and anastomosis was performed in one of 3 ways: (1) open, side-to-side, with 2 rows of No. 00 catgut to short-circuit the fecal stream without resection; (2) oblique, aseptic, end-to-end anastomosis, as described earlier in this paper, but without sulfonamide implantation; or (3) oblique, aseptic, end-to-end anastomosis with implantation of a total of 60 or 70 milligrams of sulfanilamide in the interval between the suture lines. The dogs were regularly given isotonic sodium chloride solution intravenously the day of operation, water by mouth the 2d day, milk the 3d, and horse meat and mixed table scraps were given from the 4th day.

Experimental results. The dogs usually vomited 48 hours after obstruction, and the vomitus usually became fecal in character in 72 to 120 hours. Frequently the abdomen became distended.

Eight dogs died after obstruction and before anastomosis. Two of these were obstructed in the presence of diarrhea, and died of chemical imbalance which was not understood. Two died of perforation at the site of obstruction; the first had been obstructed by division and double pursestrings, a procedure which was therefore abandoned; the other bowel perforated through a suture hole which was evidently placed too deep. One died of pneumonia, 1 of an abscess resulting from subcutaneous instead of intravenous fluid administration, and 1 died of intussusception of the whole site of obstruction as far as the pelvic colon. Finally, 1 dog was used as a control, and survived 12 days, the abdomen being clean at autopsy.

The second operation was undertaken, as a rule, after 5 to 7 days of obstruction, but there were 2 instances in which this interval was 8 days, 3 of 4 days, one of 3 days, and one of 2; all these survived.

Careful notes of the condition of the distended bowel were made at the time of most of the anastomotic procedures. In the 4 to 8 day group of animals, the ratio of the diameter of the bowel above the obstruction to that below ranged from 2 to 5.2, with a mean of 2.7 times. The actual diameter was at times as great as 6 centimeters. As Owings and Smith observed, the bowel above the obstruction usually had an edematous appearance. In 8 of the 9 instances in which definite mention was made of the color of the bowel, it was described as discolored or cyanotic. In 2 additional cases the bowel was gangrenous, 1 with a frank perforation sealed by the omentum[1]; in each of these instances the gangrenous areas were resected with a margin of less than 10 centimeters, and both recovered.

In all the 4 to 8 day group, the proximal bowel offered much less resistance to the passage of the needle than the distal bowel, and sutures could be tied only tight enough for apposition, lest they cut into the edematous proximal bowel wall. In the majority of instances, pinching of the bowel just proximal to the site of suture line failed to evoke contraction of the musculature.[2] If such a segment is tested for bursting strength, it is found to be greatly weakened below the normal level of 450 to 550 millimeters of mercury. In 9 instances in which this was checked, the mean bursting strength was 209 millimeters, the minimum was 72 millimeters and the maximum 320 millimeters.

Following reanastomosis in the successful cases, profuse diarrhea was usually observed within an hour or two. Water was usually taken the same day, and food as soon as it was offered.

From the point of view of survival, those animals which returned to a full diet and in which subsequent examination of the specimen revealed a firm anastomosis with adequate stoma were considered satisfactory; a few of these were lost in an epidemic of distemper, and some were lost in a heat wave. Those which failed to achieve normal gut function were considered failures, with the exception of 1 dog with an open and 1 dog with a closed anastomosis, which died 1 day after surgery in the heat wave which killed also some unused stock animals; these have been included as satisfactory anastomoses because

[1] This dog had been obstructed 8 days. In this animal and in one 5 day experiment the author had the privilege of testing the aseptic decompressing device devised and reported by Wangensteen (14) prior to the application of it to clinical cases. It was also used in Patient No. 9, Table I.

[2] These changes also were observed in almost all the clinical cases.

they looked excellent at postmortem examination and did not seem to have contributed to death. One dog was kept open over 2 hours on a cool day for photographs and died of atelectasis within a day; this was omitted.

The results of these experiments are summarized in Table II.

TABLE II.—ANASTOMOSIS IN THE DOG FOLLOWING ILEAC OBSTRUCTION

Type of anastomosis	Number of dogs	Unsatisfactory		Satisfactory	
		Leakage	Obstruction	Number	Per cent
Open side-to-side	4	1	1[1]	2	50
Oblique, aseptic, end-to-end Without sulfanilamide	6	1[2]	0	5	83
With sulfanilamide	10	0	0	10	100

[1] This obstruction was partial and contributed to death 11 days after operation.
[2] This resulted from clumsiness at operation, which led to a longitudinal tear near the suture line, inadequacy of blood supply resulting.

THE HEALING OF ANASTOMOSES PERFORMED ON BOWEL WHICH HAS BEEN SUBJECTED TO DISTENTION AS A RESULT OF OBSTRUCTION

Halsted devised an open end-to-end anastomosis performed with presection sutures. He pointed out several dangers which have been applied to anastomosis in general: (1) overinversion of tissue, causing either obstruction to the lumen or necrosis of the inverted tissue, or even necrosis at the suture line from tension; (2) too shallow placement of sutures, with inadequate grip and consequent tearing of the tissues, leading to loosening of the closure and peritonitis; and (3) too deep placement of the sutures, forming a tract through which peritonitis was observed to develop.

Halsted's specimens were studied microscopically by Mall, who confirmed the dangers of including mucosa in silk sutures, and observed a cyst-like adenomatous growth of mucosa through all but the serosal layers when this was done. In sections made 1 to 2 days after anastomosis, pus cells were frequently found in considerable numbers between the apposed surfaces. The mucosa did not become fully regenerated until about 3 weeks. He concluded that the inverted ridge or flange of tissue begins to unfold at about 4 weeks and eventually unfolds to leave only an area of slight thickening.

Further studies by Holman and Sabin on anastomoses made by Halsted's technique corroborate the earlier findings in most regards, but in these later observations the mucosa healed completely in 9 days. Some of the published plates show no disappearance of the inverted flange after 10 weeks.

Martzloff, Moore, and Gardner (9) studied the healing of ileum after anastomoses over clamps by the Martzloff-Burget technique. They used silk for both layers, and their results, in the main, confirm those of Mall and Sabin. Their inturned flanges flattened out much more quickly, however, i.e., in 14 days, and the mucosa became entirely healed before 6 days had passed.[1]

Gerbode employed the Martzloff-Burget technique for gastroenterostomies in dogs, using 2 layers of interrupted silk in some instances and an inner layer of running catgut and external Lembert stitches of silk in others. He observed that the tissue which had been crushed in the clamps usually dropped off in 48 hours so that a granulating bed was left, which in turn was regularly overgrown by mucous membrane at 14 to 17 days. The line of apposition showed pus cells only around the sutures, and this area had regularly healed at 11 days by proliferative fibrosis. The size of the flange began to decrease at 14 days and remained at 28 days only as an area of slight thickening.

One may conclude from these reports that healing after the closed method of anastomosis is at least as rapid as it is after the open method.

Varco, Hay, and Stevens, of this clinic, broadened the field of intestinal surgery immensely when they discovered the improvement in healing of intestinal wounds which results from the local implantation of sulfanilamide. It is their impression that application of the drug inhibits fibrinolysis by the

[1] Of interest is their finding that 8.5 per cent of their anastomoses made in this fashion leaked fatally; when they used catgut for the internal stitch, the leakage rate was 23.5 per cent; and when they omitted the internal running suture altogether, 17 per cent leaked. In the oblique, aseptic, end-to-end anastomosis described in this paper there has been no instance of leakage when performed on normal bowel in over 40 instances. This security is due at least in part to the presence of peritoneum on at least one of the inverted surfaces at all points around the line of apposition. The majority of these anastomoses were performed without sulfanilamide implantation.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

Figs. 12 to 15. Photomicrographs showing appearance of line of apposition of anastomosis made in the relief of 5 to 7 days' obstruction in the dog. ×6. Sulfanilamide implanted.

Fig. 12. Appearance at 1 day. The area crushed by the clamps has not yet sloughed. There is firm serosal sealing, and both the cotton and the catgut sutures are visible. Under high power magnification, very few polymorphonuclear leucocytes are visible around either serosa or in the line of apposition, except in those areas where the tissue had been crushed.

Fig. 13. Appearance at 6 days. Healing is secure, and there is little evidence of inflammation. A granulating bed has formed at the luminal end of the line of apposition, and the mucosa is spreading over this area.

Fig. 14. Appearance at 18 days. The granulating bed is almost covered with a thin layer of epithelium. The catgut is still present. The defect at the base of the ridge of inversion contains a few wisps of cotton suture material.

Fig. 15. Appearance at 165 days. The line of suture is recognized only by the presence of a cotton stitch. The inversion ridge has all but disappeared in this specimen.

bacteria from the intestinal lumen, and thus promotes primary union.

Procedure in microscopic and gross examination of specimens. Specimens were removed from almost all animals for sections of the suture line at varying intervals after anastomosis. They were removed, in the majority of instances, while the animals were still alive (the bowel being reanastomosed for control sections) or immediately after sacrificing by an overwhelming dose of sodium pentobarbital or ether given intravenously. Removed specimens were fixed in 4 per cent formaldehyde solution, and paraffin sections were cut at right angles to the suture line midway between mesenteric and antimesenteric borders. All sections were 6 micra thick and were stained with hematoxylin and eosin.

Microscopic findings after obstruction. Gross changes in the bowel resulting from obstruction have already been described. Microscopic examination of this distended bowel regularly reveals the following changes: edema of all layers, congestion, hemorrhage into the

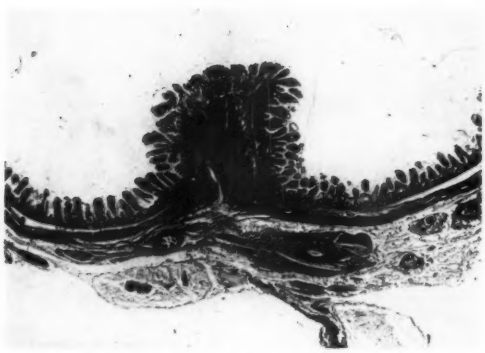

Fig. 16. a, left, An anastomosis line in a dog 235 days after performance in the relief of obstruction without sulfanilamide. The ridge of inversion is permanent, the usual result in the canine suture lines. b, A similar specimen 51 days after anastomosis. The scar in the absence of sulfanilamide is usually heavier than with the drug.

tissues in some spots, and polymorphonuclear leucocytic infiltration also of many areas. Despite these changes, 1 of the 8 day obstruction specimens was found to have the mucosa completely healed over the tissue inverted at the time of obstruction.

Healing after oblique, aseptic, end-to-end anastomosis with sulfanilamide implantation. One day after anastomosis the area crushed by the clamps has not yet sloughed (Fig. 12). There is firm sealing of the apposed serosal surfaces, and both the catgut and a cotton suture can be seen. Under higher power the line of inversion between the catgut and the necrotic crush shows some polymorphonuclear leucocytic infiltration, and a few also may be seen about both sutures. There is no evidence of mucosal regeneration.

Six days after anastomosis healing of the apposed serosal surfaces appears very secure (Fig. 13), and there is no low power evidence of inflammation. A granulating bed has formed at the luminal margin of the line of apposition, as Gerbode described, and a few leucocytes can be found here under higher power magnification. The mucosa is rapidly covering this area. The catgut and the cotton suture can be seen, neither surrounded by leucocytes.

Eighteen days after anastomosis a single layer of epithelial cells has almost covered the granulating bed at the luminal end of the line of apposition (Fig. 14). A few leucocytes are present in the mucosal edges, but not elsewhere. The catgut stitch is still present. The defect at the base of the ridge of inversion results from penetration of the mucosa by a cotton stitch.

At 48 days healing appears complete, the catgut has disappeared, and the region of the anastomosis has become difficult to find. The situation remains essentially unchanged at 165 days (Fig. 15), when the point of anastomosis can be identified only by the finding of a cotton suture beneath the serosa. In this specimen, the inverted tissue is no longer apparent, and unfolding appears to have occurred, as described by Mall.

Unfolding of the inverted flange happened occasionally in the dog experiments and usually had occurred in the late human specimens obtained, but the more common end-result in the laboratory is illustrated in Figure 16a, a 235 day old anastomosis. There is complete healing of all the layers, but a 4 millimeter ridge remains. It was regularly found that the diameter of the gut above and below the point of anastomosis became identical within 2 weeks; in 1 instance this had occurred in 6 days.

Healing after oblique, aseptic, end-to-end anastomosis without sulfanilamide implantation. In the absence of sulfanilamide, healing progressed at the same rate as with it, but throughout the process there was much greater evidence of inflammatory reaction; this reaction has been interpreted as the result of greater bacterial growth. At one day,

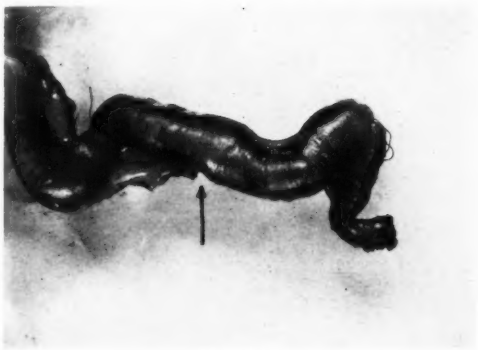

Fig. 17a.

Fig. 17b.

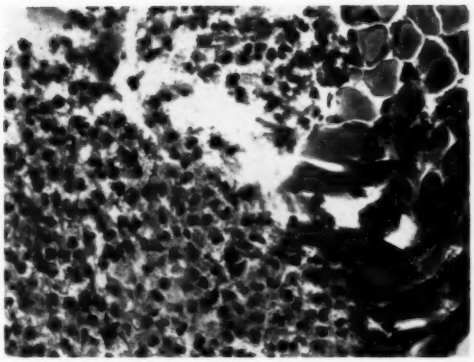

Fig. 17c.

Fig. 17. An anastomosis from a clinical case, made in the presence of obstruction 1 year before, with implantation of sulfanilamide. a, Gross appearance. The arrow indicates the point of anastomosis. b, Section through the line of apposition. ×6. The ridge has not unfolded. A piece of the silk suture is present in the defect in the ridge—it extends over to the mucosal surface. c, Under higher power, polymorphonuclear leucocytes are seen still to be present in contact with silk suture. ×215.

there is heavy leucocytic infiltration about both the sutures and also in the line of apposition. It is still present at 6 days, but no frank liquefaction is recognized. The ultimate healing is as satisfactory as with sulfanilamide implantation, but there appears to be a heavier scar left (Fig. 16b).

Healing after open anastomosis. After open anastomosis, only 3 specimens are available. In these few, the most striking finding is a heavy infiltration of leucocytes around each suture and also in the line of apposition. The inverted cuff of tissue is greater than in the closed method, and apposition is far looser and results in a heavier scar than is the case in the closed procedure. It was apparently loose apposition which resulted in leakage in 1 of the dogs.

Healing after oblique, aseptic, end-to-end anastomosis in the absence of obstruction. The mucosal repair reported above is far slower than that reported by Martzloff and his associates. With the thought in mind that obstruction might be responsible, studies were made on 11 anastomoses made in the absence of obstruction, some with and some without sulfanilamide implantation.

Healing progressed in these anastomotic sites in a fashion apparently strictly parallel to that seen after obstruction. At 7 days, when Martzloff found healed mucosa, the mucous membrane covers only ⅓ of the granulating surface. In search of some other factor, postoperative and preoperative feeding were considered. When the dogs were allowed only water and milk by mouth, it was found that at 5 days the epithelium had proliferated to the edge of the crush, which had not yet sloughed. At 11 days, healing of the mucosa is complete, and at 15 days, it was found

that glands have formed across the line of anastomosis.

Healing in clinical cases after aseptic anastomosis. A few clinical specimens have become available at varying intervals after anastomosis. In the duodenocolic anastomosis of Case 7, the specimen became available at autopsy, 9 days after operation. There was still a wide granulating area at the line of apposition internally, and a small abscess was found between mattress sutures anteriorly, as already mentioned. In Case 12, the patient had had peritonitis for nearly 3 weeks at the time of death, and there was very little healing evident; the wound edges pulled apart with minimal tension.

Two anastomoses, performed in the presence of obstruction but without strangulation, were obtained from the same patient, due to successive operations, the patient ultimately dying of peritonitis from contamination incident to a catheter enterostomy. The first was 9 days old; it shows the area of crush not yet sloughed. There are no leucocytes to be seen. The other was 24 days old at the time of death. Healing is excellent, and no leucocytes are visible; the mucosa almost covers the granulating area.

The specimen obtained from Patient No. 5, 1 year after anastomosis, shows intact healing. Grossly the suture line is difficult to find (Fig. 17). Section shows a silk stitch with polymorphonuclears about it, which is presumably being extruded into the lumen, an indication of too deep a bite. In spite of this, the amount of contraction of the suture line in a full year is too little to be demonstrable by measurement, as already mentioned.

Another year old specimen was obtained from Patient No. 7 at her second operation. The anastomosis had been performed by the Martzloff-Burget technique. The site of anastomosis was recognizable grossly by the presence of sutures beneath the serosa, and microscopically only by the abrupt change of mucosal pattern from high jejunal to lower ileac.

Healing of experimental anastomoses made at the time of obstruction. In 3 dogs, an oblique, aseptic, end-to-end anastomosis was performed 15 centimeters above the point of obstruction, which was made at the same sitting.

In the first 2, sulfanilamide was not implanted, and the 2 rows of sutures were placed as closely as possible; death occurred from perforation, one in 3 days and the other at 5 days. The 3 day specimen was autolyzed. In the other, perforation had occurred beside a perforating cotton suture on the anterior suture line midway between the angles. Microscopic examination shows a perforation through the ileac wall where a wisp of remaining cotton is visible; there is also a great sheet of polymorphonuclear leucocytes between the apposed surfaces extending to the mucosa near the first perforation; a larger piece of suture is visible in this exudate.

In the third dog, sulfanilamide was implanted, at least 2 millimeters was allowed between the two rows of sutures, and the animal was milk-fed. The anastomosis healed despite distention and fecal vomiting. The dog died 19 days after operation, living much longer than control dogs subjected to obstruction alone.

OBSERVATIONS

The clinical results and the survival rates in the animal experiments leave little doubt concerning the relative safety of the anastomotic procedure described or the advisability of primary anastomosis in preference to other procedures. The technique, if adequate in the presence of obstruction and marked degrees of distention, is patently very safe for use in elective operations. In Case 7 there may have been some postoperative extension of thrombosis, but in no other instance was this observed. It seems justifiable to conclude that this fear, entertained by many, is not well founded.

Some discussion of the reasons for certain of the steps is in order. Early anastomoses were performed by the Martzloff-Burget technique. In many dogs the bowel is sufficiently small so that the anastomosis cannot readily be made secure without inversion of enough tissue to cause necrosis or obstruction. It was for this reason that rotation of the ends with greater obliquity of placement of the clamps was first adopted.

The device described of placing the clamp on the bowel of small diameter is fully as effective when both segments are of narrow lumen, and has been in regular use for end-to-end primary ileotransverse colostomies, the standard procedure in resections of the right colon for cancer at the University Hospitals.

In the Martzloff-Burget anastomosis the internal running stitch is silk. In practice, this was found to offer too much friction, thus interfering with easy and clean inversion during removal of the clamps. Fine catgut serves admirably for this purpose, and application with an atraumatic needle minimizes tissue trauma during insertion.

Martzloff, Moore, and Gardner tried what they call the Scarff technique, namely placement of Halsted mattress sutures adjacent to the clamps without an internal running suture, but they found it impracticable because the stitches cannot be placed at right angles to the clamp and close to it with accuracy and therefore without frequently perforating the mucosa. For the reason that this procedure appeared, except for this difficulty, an ideal procedure, it seemed wisest to use the finest size of catgut that would suffice for the mechanics of the operation. The aim, therefore, is to apply the fine catgut only to hold the intestine during the placement of the important Halsted mattress stitches, and for the few minutes to an hour which are needed for serosal sealing to take place between the 2 rows of sutures.

Inasmuch as the removal of catgut is an exudative and liquefying as well as an absorptive process, it is likely to become infected in the course of healing, especially in this position. This is a further reason for the insertion of a minimum of foreign material by use of a very fine strand. It also is responsible for the impression that an expanse of serosa perhaps 2 millimeters wide should be left between the 2 layers of sutures, for healing would be less kindly if infection of the silk sutures were to occur. With observance of this principle, an anastomosis, made at the time of obstruction a few centimeters below it, healed despite distention, vomiting, and finally death from obstruction. The question needs more study.

The evidence presented in this paper indicates that unfolding of the inverted flange cannot be counted on to enlarge the stoma, at least not within months. One must therefore invert enough tissue so as to assure a band of serosal approximation between suture lines, but not enough to interfere to any extent with the lumen. The obliquity of the suture line in the present technique minimizes the danger of obstruction from this source.

The data presented in this paper also are in line with the conclusions of Halsted and Mall that too deep placement of sutures is dangerous. Of the 4 perforations observed following the use of this anastomosis in the presence of obstruction (3 dogs and 1 patient), 1 at least occurred around a cotton suture that had pierced the mucosa. The placement of stitches which catch the bulk of the muscle but no submucosa would seem a less hazardous error only if they are tied loosely enough not to tear the tissues at the time.

With regard to the rate of healing in the presence of obstruction, the data presented indicate that the deeper layers heal fully as fast and securely as by other methods or in the absence of obstruction. With regard to the mucosa there is some question. The experimental animals were fed following obstruction in order to simulate the situation found in clinical cases, and they therefore had food and other matter in the intestine at the time of anastomosis. In any case, the mucosa healed in anastomoses after obstruction as rapidly as in unobstructed bowel in which the dogs were fed. The faster rate of mucosal healing, which has been reported by Sabin and Martzloff, could be approximated by starvation of the animals.

CONCLUSIONS

1. An oblique, aseptic, end-to-end anastomosis designed for use on intestine in the presence of obstruction is described.

2. A series of 16 resections for strangulating obstructions in clinical cases resulted in 2 deaths and 14 recoveries.

3. Laboratory study of this anastomosis indicates that it is highly reliable, either in the presence or absence of obstruction.

4. Healing in bowel that has been obstructed 5 to 7 days and then anastomosed by this

technique is apparently as rapid and secure as in the absence of obstruction.

5. Late contraction along the suture line apparently does not occur.

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WOUND HEALING—EXPERIMENTAL AND STATISTICAL STUDY

III. Experimental Observations

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THE present study was undertaken in order to compare the effects of the most commonly used sutures on wound healing. The technique used by one operator was employed throughout the experiment. Fine suture materials of comparable size and tensile strength were used.

Several methods of quantitatively estimating wound healing have been devised. Carrel and Hartman in 1916 described a method of measuring the rate of cicatrization of skin defects. The size of the wound was traced on cellophane and the area was then determined by means of a planimeter. Measurements were made daily. This method is limited to superficial defects. From these studies, Du Nouy (5–8) was able to evolve a series of mathematical equations expressing the laws of cicatrization of surface wounds. Douglas attempted to simplify the planimeter method used by Carrel and Du Nouy by employing a gravimetric method for determining the superficial area of wounds. A tracing of the exact pattern of the wound was made and then transferred to bond paper of known weight per square centimeter. The bond paper pattern was then weighed, the weight divided by a constant (the weight of one square centimeter of the paper) and the exact area in square centimeters determined.

Howes and Harvey (10) and Howes, Sooy, and Harvey (11) employed a thread tester to determine the strength of wounds. This procedure consisted of determining the tensile strength required to pull the wound edges apart. After the wound was excised, it was placed in a standard thread testing machine, and its tensile strength was determined. Whipple has used a similar method, and Preston has recently used a simplified modification of this method.

In his studies of fibroplasia and wound healing Harvey determined the tensile strength of a wound by disruption with air pressure. The rat stomach was used for most of these studies. The organ was removed, the esophagus was tied, and a cannula was inserted into the duodenum. Air was admitted at a uniform rate through the cannula, until disruption of the wound or the stomach occurred. The pressure was measured by a mercury manometer recording on a revolving drum. This method is restricted to studies of healing wounds in hollow viscera.

Lanman and Ingalls modified this method. They used a mercury sphygmomanometer, the closed circuit of which was connected to a free length of rubber tubing to which a lumbar puncture needle was attached. The needle was inserted into the peritoneal cavity or into a hollow viscus, and the air pressure was increased until disruption occurred.

Burr, Harvey, and Taffel (1) and Burr, Taffel, and Harvey (2) have recently described an electrometric method of measuring the healing of wounds. This procedure is based on the fact that rapidly dividing masses of cells generate an electric potential which can be measured.

In our studies we used the method of Lanman and Ingalls, with a slight modification. A detailed description of our method follows.

METHOD

Shaving of the abdomen of each rat was done 24 hours prior to operation so that incidental cuts might have time to heal. Instruments, towels, and gloves were sterilized. The room used for these experiments contained

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Parts I and II are to appear in later issues of the *International Abstract of Surgery*.

many other animals and the air was probably highly contaminated. Ether narcosis was employed and maintained. The abdomen was prepared with a mercurial antiseptic, and the field was draped with a sterile towel. An incision exactly 3 centimeters in length was made just to the right of the midline and half way between the xiphoid and the base of the penis. The abdomen was opened with a sharp scalpel, so that traumatization of tissues was minimal. Bleeding was slight and bleeding points were easily controlled with light pressure. The use of ligatures to obtain a dry field was not found necessary. The peritoneal cavity was not explored and the abdominal viscera were not molested.

Six equally spaced sutures of the material to be tested were placed in the peritoneum and in the fascia. Because of the delicacy of these structures it was necessary to take a small bite of rectus muscle with each of the sutures. Fine, full circle, half inch, French eye cutting edge needles were used in order to reduce forceps manipulation to a minimum. Interrupted sutures of No. 0000 chromic and plain catgut of a standard brand, Deknatel serum proofed B silk, Deknatel B nylon, Pillings No. 36 alloy steel wire, and Gudebrod's No. 000 cotton were used. Catgut sutures were tied with triple throw knots, with all the throws square, and the sutures were cut about 3 millimeters from the knot. Silk, cotton, and wire were tied with true square knots and the sutures cut about 1 millimeter from the knot. It was found that nylon sutures slipped unless tied with four knots with all throws square, and occasionally even these sutures were found untied. Therefore, these sutures were tied with a quadruple knot and cut 1 millimeter from the knot. Strangulation of tissues was carefully avoided. The edges of the sutured wounds were approximated as closely as possible. The skin was not utilized in the experiment and was therefore closed with a continuous suture.

The skin was saturated with ether and the wound, while still wet, was covered with a piece of clean unsterilized adhesive tape to prevent the animals from removing the skin sutures. The adhesive tape usually remained in place until the 3d or 4th postoperative day, by which time sufficient healing had occurred to prevent exposure of the underlying fascia.

Animals were sacrificed daily until the 9th day, and thereafter on the 13th, 21st, 31st, 45th, and 62nd days. Chloroform was used for this purpose. Immediately after the death of the animal, the wound area was painted with a mercurial antiseptic. Skin sutures were removed with sterile instruments, the skin wound was opened, and cultures were taken. The swab was first passed on a blood agar plate and then placed in beef broth.

The skin was not tested since it is of secondary importance in the healing of abdominal wounds. It was dissected free at the level of the superficial fascia until the entire wound and both lower abdominal quadrants were exposed. Pressure studies were then made.

A sharp, No. 24 hypodermic needle was inserted into the peritoneal cavity through the left lower quadrant. It was connected to a short rubber tube which in turn was connected to the air bulb of a sphygmomanometer. Air was slowly pumped into the peritoneal cavity until the abdominal wall was raised from the peritoneal viscera. This procedure was necessary so that loops of intestine would not adhere to a second needle inserted to measure the intraperitoneal pressure. A second No. 24 hypodermic needle was then inserted into the peritoneal cavity through the right lower quadrant. This needle was connected by means of rubber tubing to a mercury containing U tube calibrated in millimeters. The intraperitoneal pressure was increased slowly 2 millimeters at a time, until disruption occurred, either of the wound, the pelvic peritoneum, the iliac vessels, or the scrotum. Most wounds which disrupted did so suddenly, and over most of their extent. Occasionally, a few bubbles of air were seen coming from the wound, and partial or complete disruption occurred shortly thereafter. Following the leakage of air it was difficult to raise the mercury column more than 2 to 3 millimeters. By proceeding slowly and noting the level at which the mercury column no longer rose, a fairly accurate reading could be obtained. In some of the animals disruption occurred not in the wound but in one of the previously indicated areas, the most frequent being the pelvic peritoneum, which disrupted suddenly and dis-

TABLE I.—EXPERIMENTAL MATERIAL

Days after operation	Number of animals available for study						Total animals
	Suture material						
	Catgut		Silk	Wire	Cotton	Nylon	
	Plain	Chromic					
1	3	3	5	5	5	5	26
2	3	3	5	5	5	5	26
3	3	3	6	5	5	5	27
4	4	3	5	5	5	5	27
5	3	3	5	5	5	5	26
6	3	3	5	5	5	5	26
7	3	3	5	5	5	5	26
8	3	3	5	5	5	5	26
9	3	3	5	5	5	5	26
13	2	1	2	2	2	2	11
21	1	1	2	2	2	2	10
31	1	1	2	2	2	2	10
45	2	..	2	2	2	2	10
62	1	1	2	2	3	2	11
Totals	35	31	56	55	56	55	288

charged air into the tissues of the thigh. Occasionally, air was discharged into the thigh suddenly or slowly through rents in the pelvic peritoneum about the exit of the femoral vessels, and once into the scrotum.

After pressure readings were completed the entire wound was excised and placed in formalin for histological study.

Fine hypodermic needles were used since it was observed that large caliber needles frequently caused subcutaneous emphysema due to leakage of air about the needle. Animals in which subcutaneous emphysema developed, and those in which air leaked about the needle before disruption occurred, were discarded. In rare instances bits of muscle plugged the needle, and pressure readings could not be obtained.

Although this method, like that of Harvey and that of Lanman and Ingalls, does not give the absolute strength of the wounds, relative values of the strength of wounds could be obtained which were adequate for purposes of comparison.

Bacteriological study of wounds was restricted to the determination of aerobic organisms only.

TABLE II.—PRESSURE NECESSARY TO CAUSE DISRUPTION OF ABDOMENS OF UNOPERATED ANIMALS (CONTROLS)

No. of animal	Pressure in mm. of mercury	No. of animal	Pressure in mm. of mercury
1	93	11	93
2	98	12	108
3	93	13	95
4	87	14	96
5	101	15	115
6	87	16	95
7	93	17	90
8	96	18	104
9	93	19	108
10	98	20	111

Total animals, 20; mean tensile strength, 97.7 millimeters; standard error of the mean, 1.75 millimeters.

Hematoxylin and eosin sections of all wounds were studied. These sections did not include the skin of the abdominal wall.

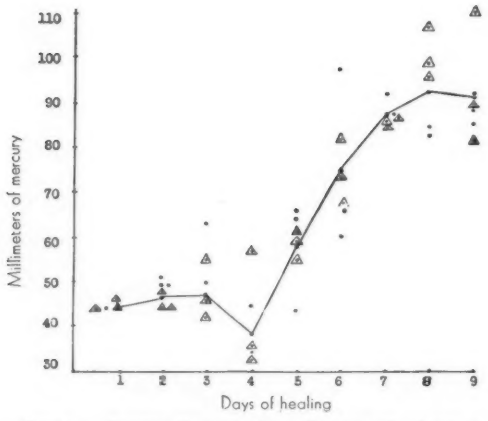
MATERIAL

Young, white adult male rats, bred from stock purchased from a commercial breeder, were utilized in the experiment. Data on 288 operated upon animals (Table I, IV-A, V-A, VI-A, VII-A, and VIII-A)[1] are reported. A group of 20 rats was used as a control.

Disruption occurred in the peritoneum of the 20 control animals, at an average pressure of 98 millimeters plus or minus 5.2 millimeters of mercury (Table II). The range of observations in this control group was from 87 to 115 millimeters of mercury. The standard error of the mean was 1.75 millimeters.

From the value of the mean tensile strength, and the value of the standard error of the mean, we may draw some conclusions as to the probable "true" value of the mean tensile strength of the abdomens of healthy rats. Since 99.7 per cent of the sample means vary from the population mean by not more than plus or minus three times the standard error of the mean, we may conclude that the true mean tensile strength, that is, the mean tensile strength of the abdomens of all rats similar to the ones used in this study, is almost surely not less than 92.8 millimeters nor more than

[1]Tables IV-A, V-A, VI-A, VII-A, and VIII-A will appear in Part IV in the October issue.



Graph 1. Scatter diagram of tensile strength of catgut sutured wounds. Dots indicate plain catgut, dot in triangle, chromic catgut.

103.2 millimeters. The fiducial probability, or degree of reasonable expectation, is 997 out of 1,000 that the true mean lies between 92.8 and 103.2 millimeters.[1]

TENSILE STRENGTH OF SUTURED WOUNDS

Catgut. The data relative to the strength of catgut sutured wounds are presented in Table IV-A and charted in Graph 1. There was little difference in mean tensile strength from day to day between wounds sutured with plain and those sutured with chromic catgut (Table III).

[1] Croxton, F. E. and Cowden, D. J. Applied General Statistics, p. 314 New York: Prentice Hall, Inc., 1939.

TABLE IV.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH CATGUT, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury, necessary for disruption					t	n	Value of "t" at .01 level	Remarks
Days after operation								
1	2	3	4	5				
44	47.5				2.8	10	3.17	N.S.G.
	47.5	47			.09	10	3.17	N.S.L.
		47	38		1.40	11	3.11	N.S.L.
			38	58	4.0	11	3.11	S.G.

N.S.G. Not significantly greater.
N.S.L. Not significantly less.
S.G. Significantly greater.

TABLE III.—COMPARATIVE TENSILE STRENGTH OF PLAIN AND CHROMIC CATGUT SUTURED WOUNDS

Days post-operative	Mean pressure, in mm. of mercury, necessary to disrupt wounds		Number of animals treated		Degrees of freedom	Fisher's "t" test*	Value of "t" at .01 probability level	Remarks
	Plain catgut	Chromic catgut	Plain catgut	Chromic catgut				
1	44	45	3	3	4	.12	4.60	N.S.†
2	50	45	3	3	4	3.27	4.60	N.S.
3	46	48	3	3	4	.17	4.60	N.S.
4	35	42	4	3	5	.91	4.03	N.S.
5	58	58	3	3	4			N.D.‡
6	75	75	3	3	4			N.D.

*For an explanation of the application of Fisher's "t" test, see *Applied General Statistics*, by Croxton & Cowden, pp. 325–331.
†Not significant.
‡No difference.

The data presented in this table apply only in those instances in which disruption occurred in the wound, because we have no measure of tensile strength of wounds in those instances in which disruption occurred in other sites. When disruption does not occur in the wound, the tensile strength is at least as great, and possibly greater, than that of the pelvic peritoneum.

As shown in Table III, from the 1st through the 4th day nonsignificant differences[2] in mean

[2] Whenever mention is made that there is a significant difference—either a significant increase or a significant decrease—this means a statistical significance, as indicated by the fact that the ratio of the difference between the two means in question (taken by subtracting the second from the first, in a temporal sense) to the standard error of the difference between the two means, is greater than the value of this ratio at the selected critical probability level, which in these cases is taken to be .01 level of significance.

TABLE V.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH SILK, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury, necessary for disruption					t	n	Value of "t" at .01 level	Remarks
Days after operation								
1	2	3	4	5				
77	98				3.49	8	3.36	S.G.
	98	40			13.1	9	3.25	S.L.
		40	82		26.2	8	3.36	S.G.

S.G. Significantly greater.
S.L. Significantly less.

TABLE VI.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH COTTON, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury, necessary for disruption					t	n	Value of "t" at .01 level	Remarks
Days after operation								
1	2	3	4	5				
64	74				3.98	8	3.36	S.G.
	74	60			7.22	8	3.36	S.L.
		60	71		3.26	8	3.36	N.S.G.
			71	86.5	4.01	7	3.50	S.G.

S.G. Significantly greater.
S.L. Significantly less.
N.S.G. Not significantly greater.

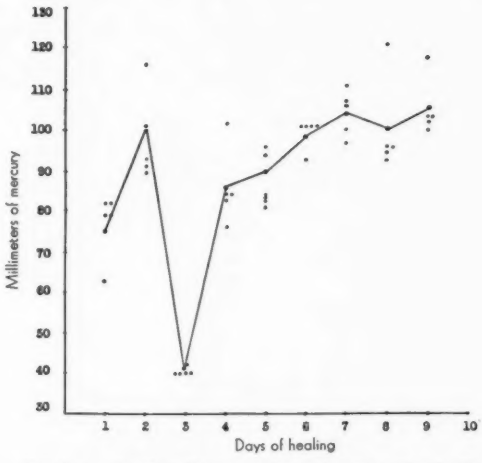
tensile strength were observed between wounds sutured with plain and those sutured with chromic catgut. On the 5th and 6th days no experimental difference was observed in the means. On the 7th day there was not sufficient material for a test because only one of three wounds sutured with chromic catgut disrupted.

From these results it may be seen that so far as mean tensile strength is concerned there is no difference between the effect of chromic and the effect of plain catgut. Statistically speaking, we have cast no doubt upon an hypothesis that the true difference between the mean tensile strength of wounds sutured with chromic catgut and of those sutured with plain catgut is zero. Therefore, when comparing the results of the use of catgut with the results of

TABLE VII.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH WIRE, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury, necessary for disruption					t	n	Value of "t" at .01 level	Remarks
Days after operation								
1	2	3	4	5				
65	64				.3	8	3.36	N.S.L.
	64	52			3.74	8	3.36	S.L.
		52	75		12.1	8	3.36	S.G.

N.S.L. Not significantly less.
S.L. Significantly less.
S.G. Significantly greater.



Graph 2. Scatter diagram of tensile strength of silk sutured wounds.

the use of the nonabsorbable sutures, we shall not differentiate between catguts, but shall combine them into one catgut group.

A lag period of 4 days was observed. This period, with reference to tensile strength of healing wounds, is that period just preceding the initiation of a continued and uninterrupted increase in tensile strength.

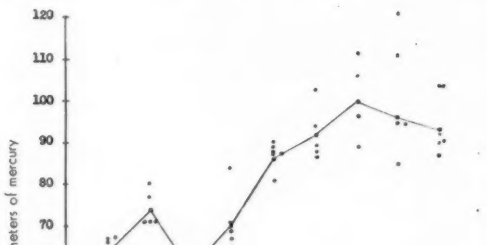
Increase in tensile strength of catgut sutured wounds did not occur until the 5th day (Table IV). There was a slight increase in mean tensile strength by the second day, and then a decrease during the remaining 2 days of the lag period. However, the tensile strengths on these days were not significantly greater or less than on the day immediately preceding. The increase immediately after the end of the

TABLE VIII.—DATA ON TESTS TO ASCERTAIN SIGNIFICANCE OF INCREASES AND DECREASES IN MEAN TENSILE STRENGTH OF WOUNDS SUTURED WITH NYLON, DURING AND DIRECTLY FOLLOWING THE LAG PERIOD

Mean pressure, mm. mercury, necessary for disruption					t	n	Value of "t" at .01 level	Remarks
Days after operation								
1	2	3	4	5				
65	58				1.00	8	3.36	N.S.L.
	58	79			3.75	8	3.36	S.G.

N.S.L. Not significantly less.
S.G. Significantly greater.

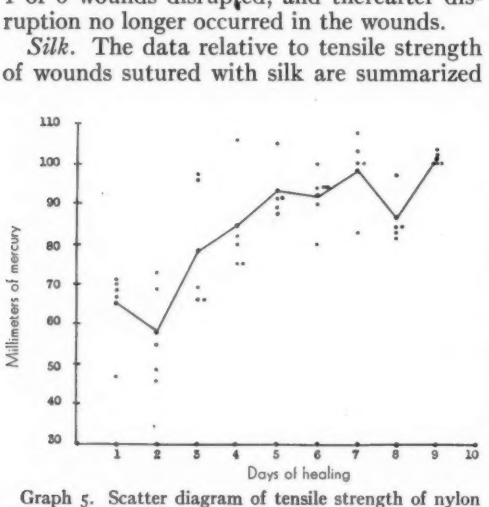
Graph 3. Scatter diagram of tensile strength of wire sutured wounds.



Graph 4. Scatter diagram of tensile strength of cotton sutured wounds.

lag period, that is, from the 4th to the 5th day, was significant. On the 4th postoperative day the wounds were actually weaker than during the first 3 days. A similar phenomenon was observed at some time during healing in all wounds, irrespective of the type of suture material used. Beginning with the 5th day the mean pressure necessary to cause disruption increased rapidly. On the 7th day 3 of 6 wounds disrupted. On the 8th day there were no wound disruptions. On the 9th day only 1 of 6 wounds disrupted, and thereafter disruption no longer occurred in the wounds.

Silk. The data relative to tensile strength of wounds sutured with silk are summarized in Tables V and V-A and charted in Graph 2. The lag period in silk sutured wounds persisted for 3 days, and actual increase in tensile strength began on the 4th day (Table V). There was an increase in mean tensile strength by the 2d day and a decrease from the 2d to the 3d day. In each instance, the variation from one day to the next was significant. Likewise, the increase immediately following the lag period was significant. In the case of silk sutured wounds the lag period was one day shorter than in the case of catgut sutured wounds, 3 days as against 4, and in addition, the increases and decreases in tensile strength of silk sutured wounds during this period were significant, whereas they were not significant in the case of catgut.



Graph 5. Scatter diagram of tensile strength of nylon sutured wounds.

Following the lag period, the tensile strength of the silk sutured wounds increased very rapidly and beginning with the 6th day disruption no longer occurred in the wound. On the 4th day 4 of 5 wounds disrupted, and on the 5th day, 1 of 5 wounds disrupted.

Cotton. The data relative to the tensile strength of cotton sutured wounds are summarized in Tables VI and VI-A and shown graphically in Graph 4. There was a significant increase in mean tensile strength of the wound from the 1st to the 2d day, and a significant decrease from the 2d to the 3d day. From the 3d to the 4th day, there was an increase in mean tensile strength which was not

significant and from the 4th to the 5th day an increase which was significant (Table VI).

The picture presented here is different from that shown in catgut and silk sutured wounds. In these 2 instances, there was first, an increase in mean tensile strength then a decrease, then a significant increase. This last increase occurred directly following the lag period. In fact, this increase may be associated with the beginning of the post-lag period. It was always significant. However, in the case of cotton, the increase directly following what, in the case of the two suture materials previously described, would have been the end of the lag period, was not significant. The increase does not become significant until we pass from the 4th to the 5th day. The question arises as to the interpretation of this phenomenon. Is the lag period in the case of cotton 3 days long or 4 days long? It would seem from the statistical results that the lag period is 4 days in length and not 3 days, for the reason that the increase from the 3d to the 4th day is not significant.

The tensile strength of the wound increased rapidly beginning with the 4th day, and by the 6th day disruption no longer occurred in the wound. On the 5th day, 3 of 5 wounds disrupted.

Wire. There was a lag period of 3 days in wound sutured with alloy steel wire, with a drop in tensile strength observed on the 2d and 3d days. Table VII presents the results of an analysis of the increases and decreases in mean tensile strength during and directly following the lag period. The decrease observed from the 1st to the 2d day was not significant but the increase from the 2d to the 3d day was significant. The increase in strength directly following the lag period, that is, from the 3d to the 4th day, was significant.

Following the lag period the tensile strength increased rapidly and beginning with the 6th day, disruption no longer occurred in the wound. Data regarding these observations are summarized in Table VII-A and charted in Graph 3.

Nylon. The data relative to the tensile strength of nylon sutured wounds are summarized in Tables VIII and VIII-A and illustrated in Graph 5.

The observed lag period in wounds sutured with nylon persisted for 2 days (Table VIII).

The lag period in nylon sutured wounds was the shortest of all, and was similar to that of wire sutured wounds in that there was no increase, significant or otherwise, preceding the decrease which in every case marked the last day of the lag period. There is just one qualification to this statement. In the case of cotton, the statistical evidence so far uncovered has not been sufficient to set definitely the end of the lag period, and therefore we cannot include cotton in our remarks.

Tensile strength in nylon sutured wounds increased rapidly beginning with the 3d day. On the 5th and 6th days only 1 of 5 wounds disrupted. Thereafter disruption occurred only in the pelvis.

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ACUTE OBSTRUCTIVE CHOLECYSTITIS AND THE APPLICATION OF THE PRINCIPLES OF ITS RATIONAL TREATMENT

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IN any case of acute obstructive cholecystitis, operation will be necessary sooner or later if the ultimate cure of the patient is to be achieved. Consequently the question of importance which arises in every case of this disease is that of the time when it should be performed and, in particular, whether it should be undertaken as an emergency measure during the attack. Although it is true that the majority of patients will recover spontaneously from their acute attack and therefore can be dealt with by elective surgery at a later date, the knowledge that this is so can prove a dangerous possession; there is little doubt that a more than occasional case has terminated fatally from a peritonitis, caused by perforation of the gall bladder following upon gangrene, as a result of this knowledge having given rise, in the minds of those responsible for treatment, to the false hope and expectation that conservative measures alone would suffice to bring about the recovery of the patient from his attack. Such deaths give rise to two surmises, the first, that timely surgical intervention would have averted these catastrophes and the second, that at some period during the fatal attack the indications for such intervention must have been present but went unheeded.

The decision of whether operation should be undertaken during an attack will always remain of the "hit or miss" variety until and unless these indications are recognized as such. The ability to recognize them depends essentially upon a knowledge of the pathology and the symptomatology to which it gives rise, allowing of an interpretation of the latter in terms of the former. Treatment based upon this knowledge constitutes the only logical or rational treatment and a striking feature of the literature, which cannot but lead one to the conclusion that this form of treatment is not practiced in general, is the signal lack of mention of specific indications for operation. This omission in the literature is not only largely responsible for the confusion which has arisen regarding the time when operation should be undertaken but also indicates that the rational treatment has not been understood and therefore not applied.

Because of the fundamental importance of an understanding of the pathology, this aspect of acute obstructive cholecystitis will be summarized and briefly described also will be the principles of treatment which follow as the logical sequel of its consideration.

1. Both obstruction of the outlet of the gall bladder and acute inflammation in its wall play a part in establishing the disease, but its outcome is largely determined by the obstructive element. While the commonest cause of obstruction is impaction of a stone in the region of the cystic duct, it may also result from the occlusion of this duct by inflammatory edema.

2. The result of this combination occurring in the gall bladder is an increase in its intravisceral tension (such as will occur in any hollow muscular viscus which happens to become the seat of this combination). This increased tension is brought about through augmentation of the fluid contents of the gall bladder by both exudation and transudation into its lumen, the former a result of the inflammatory reaction, the latter following congestion of the mucosal and submucosal veins and capillaries consequent upon compression of the blood vessels, passing through the wall, during the forcible contractions of the unstriated muscle, these contractions representing Nature's attempt to overcome the obstruction.

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3. This increased tension may become so acute as to interfere with the blood supply and may do so to such an extent that gangrene of the gall bladder, to be followed later by perforation and extravasation of its contents, will occur. This "tension" gangrene always begins at the spot farthest from the source of blood supply and so, in the case of the gall bladder, first appears at the fundus.

Thus the following represents a synopsis of the simple, but ill understood, pathology of this condition:

Acute Obstruction + Acute Inflammation
↓
Increased Intravisceral Tension
↓
Interference with the Blood Supply
↓
(tension) Gangrene
↓
Perforation
↓
Peritonitis

4. It is obvious from the pathology, as here outlined, that the outcome in any given case depends upon whether or not the increased tension within the gall bladder is relieved. If left to Nature it may be relieved in one of two ways: (a) The obstruction is overcome or removed by natural means (e.g. the dislodgment of a stone obstructing the outlet) so allowing the contents to escape *per vias naturales*. In this event the need for surgical intervention does not arise for the patient will recover spontaneously from the attack. In such a case, elective surgery can be undertaken at a later date. (b) By escape of the contents through a rupture of the gall bladder after gangrene has occurred, this catastrophe representing the natural relief of the increased intravisceral tension in the gall bladder in the presence of an obstruction of its outlet which Nature herself is unable to remove or otherwise overcome. It is in the prevention of this dangerous possibility, which materially increases the chances of a fatal outcome, that surgery assumes its important rôle for, once the pathological changes have progressed to the stage when Nature herself is unlikely to relieve the increased intravisceral tension except by extravasation of the contents of the gall bladder through a rupture in its gangrenous wall, the obvious and rational procedure is to relieve it by surgical intervention before this catastrophe has had time to take place. The clinical recognition of this stage is therefore of crucial importance.

5. The most important single clinical manifestation which warrants the assumption that the pathological changes have progressed to this stage, and which therefore indicates that the time has arrived to operate for relief of the increased intravisceral tension if the more serious terminations of the disease are to be prevented, is the development of a tender, palpable mass in the right upper abdominal quadrant. The reason for this lies in the pathological significance of this clinical finding for it tells us that the gall bladder has undergone marked changes, having become grossly enlarged and tensely distended, the result of its increasing fluid contents having been unable to escape through the cystic duct because of the obstruction present in this region and thus giving rise to an increase in the intravisceral tension of dangerous degree. It might be mentioned that, if noted early in its development, this mass will present the typical characteristics of a distended gall bladder as regards shape, definition, dullness on percussion, and relations. Later, with extension of the inflammation to the visceral peritoneum the gall bladder usually becomes buried in omentum and the mass, while retaining the gall-bladder relations, becomes more easily detectable because of the increase in its size but loses the shape and definition of the free gall bladder and at the same time tends to become more fixed. Other important manifestations indicating a progressive pathology (and usual accompaniments of the sign just mentioned) are a continuously increasing pulse rate, a spreading rigidity of the abdominal muscles in the gall-bladder region, and a deterioration of the patient's general condition.

In a recent article (6) the writer dealt in greater detail with these general principles governing the rational treatment of acute obstructive cholecystitis, but it is realized that those who are unfamiliar with them may find that difficulties arise in their attempts to apply them to the individual case. Since their ultimate effectiveness depends essentially upon this application being carried out successfully,

the writer believed it would be of help to present and discuss the following two representative cases of the disease managed in accordance with these principles.

CASE 1. Mr. J. R., aged 66, seen first about 7:00 p.m. on December 6, 1939. This man had begun to have an attack of typical biliary colic some 4 hours previously and gave a history of several similar attacks during the past few years. He had never been jaundiced. He stated that this attack was the most severe he had ever experienced and that there had been some upper abdominal discomfort for several days before the onset of the acute pain. The patient was in great distress because of the severity of the pain which was causing him to roll about the bed in agony and was accompanied by nausea and vomiting. His pulse and temperature were both normal and examination of the abdomen disclosed a complete absence of any tenderness, rigidity, or palpable mass. Sedatives were prescribed in the hope that this attack would pass off as those in the past had done. He was seen the following morning about 8:30 a.m. He had had a poor night, having obtained little sleep because of the pain; colic-like exacerbations had been frequent with accompanying nausea and vomiting, the vomitus retaining its character of a greenish, bitter fluid. His pulse had increased to 90 beats per minute and his temperature was 98.8 degrees F. Examination of the abdomen now disclosed the presence of definite tenderness over the gall-bladder region accompanied by an involuntary rigidity of the upper part of the right rectus abdominis muscle; there was a questionable mass in the gall-bladder area, but one could not be quite certain of its presence at this time. The provisional diagnosis of early acute obstructive cholecystitis was now made and the patient urged to enter hospital for further observation. After admission to the Santa Barbara Cottage Hospital, morphia was administered for the pain and intravenous therapy begun to replace lost fluids. Urinalysis was negative and the leucocyte count was 16,350 per cubic millimeter of blood, with polymorphonuclear cells accounting for 89 per cent. The patient was seen again about noon. He looked worse than when seen earlier; no jaundice was present; his temperature was now 99.6 degrees F. and his pulse had increased to 110. On examination of the abdomen he was more tender, the area of rigidity had increased and now there was no doubt about the presence of a palpable mass in the region of the gall bladder under the rigid musculature. This mass measured some 6 centimeters in diameter, moved slightly on respiration, was dull on percussion and its lower edge could be well defined. It was advised that operation should be undertaken as soon as arrangements could be made and it was begun about 3:00 p.m., i.e. some 24 hours after the onset of his attack. Through a Kocher subcostal incision—that often employed by the writer in his explorations of the biliary tract—the peritoneal cavity was opened and the omentum was found enveloping the gall bladder. It was readily separated from the gall bladder to reveal that viscus the color of a plum, grossly enlarged, and tensely distended. Cholecystectomy was performed without difficulty, the operation being followed by uneventful recovery.

The gall bladder was full of dark bilious fluid under great tension and no stones were present. The wall was greatly thickened and edematous, and the mucosal surface varied in color from dark red in the region of the neck to black at the fundus. The cystic duct was stenosed to such a degree that only with difficulty could a fine probe be inserted into it.

Pathological examination of the excised gall bladder confirmed the clinical diagnosis of acute cholecystitis and showed the presence of gangrene of the fundal mucosa.

Several points of interest arise in connection with this case. We were fortunate in seeing this patient so early in his acute attack for this enabled us to observe the progress of the case almost from the onset. Can any significance be attached to the upper abdominal discomfort which was present for several days before the onset of colic? It is suggested that this was due to a mild degree of intramural inflammation resulting in some dysfunction of the gall bladder and in a sufficient degree of edema to cause eventual obstruction of the cystic duct, the stenosis of the duct, probably due to fibrosis resulting from previous inflammation, predisposing to the earlier occurrence of the obstruction. The onset of biliary colic indicated that an acute obstruction to the outlet of the gall bladder had taken place, the colic being due to the increased forcible contractions of the unstriated muscle of the gall-bladder wall, representing the attempt by Nature to overcome the obstruction. When the patient was first seen and no abnormal physical findings were present, the only diagnosis which could be made was biliary colic due to acute obstruction of the outlet of the gall bladder. The question of prognosis, therefore, depended upon whether the obstruction would be relieved, as it had been on previous occasions, with disappearance of symptoms, or whether it would persist, with the possible development of the condition we know as acute obstructive cholecystitis. This question arises in every case of biliary colic—just as the severe colic dominates the clinical picture, so obstruction of the outlet of the gall

bladder dominates the pathological one. That the pathology was progressive became evident the next morning when both tenderness and rigidity were found, presumably due to contiguous irritation of the parietal peritoneum by the gall-bladder serosa. These new developments, together with the persistence of the biliary colic, appeared sufficient to justify the provisional diagnosis of early acute obstructive cholecystitis, but the writer was not of the opinion (and never is in similar cases) that there was present at this time any indication for operation as an emergency measure, for at this early stage, the chances of relief of the obstruction, with recovery from the attack, ordinarily exceed those of its persistence, with progression of the pathology. However, clinical manifestations which point to this diagnosis should nevertheless be regarded as signals calling for close observation of the patient.

The presence of a questionable mass at this time pointed to the possibility of distention of the gall bladder and, if this conjecture were correct, to the probability that a definite mass would appear sooner or later as a result of a continued increase in size of the gall bladder and the envelopment of this viscus by the omentum playing its usual protective rôle. This probability became a certainty within a few hours, showing the rapidly progressive nature of the pathological process with which we were dealing, for some 20 hours only had elapsed since the first examination had disclosed an abdomen in which there was no tenderness, rigidity, or palpable mass. This finding indicated at once that the gall bladder had become tensely distended and enlarged much beyond its size at the beginning of the attack (when it was not palpable at all). The only possible explanation for these rapidly progressive changes was that they represented the result of the combination of obstruction and inflammation occurring together in this organ and indicating the presence within the gall bladder of a tension acutely increased to a dangerous degree. The pathological process had therefore progressed to the stage when, according to the rational treatment, it was considered safer to relieve the increased intravisceral tension by surgical intervention than to leave its accomplishment to Nature in the hope that she would do this *other than* by gangrene and perforation. Consequently the patient was advised that the time had come when operation should be undertaken as soon as possible. To have decided at this time that conservative treatment should be adopted would have appeared to the writer an indication of lack of understanding and appreciation of the pathological significance of this clinical manifestation.

It was interesting to observe the continuous increase in the pulse rate, a feature which could not have been ignored as indicating the progressive character of the pathological process however much the lack of other clinical manifestations might have tended to mask this progression. As it was and, in the writer's experience, as is usual, other clinical features confirmed the behavior of the pulse as further indications that the patient's condition was steadily becoming worse.

The findings at operation were exactly those which were expected, namely, a grossly enlarged and tensely distended gall bladder, thick walled, plum-blue in color and enveloped by inflamed and matted omentum. Immediately on withdrawal of the trocar from the cannula inserted through the fundus to evacuate the fluid contents and so facilitate the performance of cholecystectomy, dark colored bile gushed forth, showing the great, and quite abnormal, tension under which it had been imprisoned in the gall bladder. Here, then, was a case of such severity that obvious interference with the blood supply occurred within 24 hours—no hollow muscular viscus will become this color except as a result of interference with its circulation, for inflammation alone does not produce this type of change—and yet no stones were present. Such a case as this affords as definite a proof, from the pathological standpoint, of the fallacy of the theory advanced by Denton that interference with the blood supply is due to pressure on the cystic vein and lymphatics by an impacted stone, as did Kreider's work on anatomical grounds. Moreover, *the pathological condition of the gall bladder disclosed at operation provided ample evidence that the clinical manifestations, on the presence of which the decision to operate*

was made, had been interpreted correctly as indicating the advisability of immediate operation. The fact that gangrene of the fundal mucosa had occurred in such a short time after the onset of symptoms indicated that the pathological process was rapidly progressive and there seems little doubt that conservative treatment would have failed to prevent its further progression by overcoming the obstruction and thus relieving the increased intravisceral tension by allowing escape of the contents through the cystic duct. The result of this failure would have been an increasing amount of interference with the blood supply, due to increasing intravisceral tension, leading to a spread of the gangrene to involve the entire thickness of the gall-bladder wall, with subsequent perforation and extravasation of its contents. This catastrophe, toward which the patient was being led rapidly by the swift progress of the lesion was, and could only have been, averted by timely surgical intervention.

The increased white cell count with a polymorphonuclear leucocytosis indicated that there was present an inflammatory element in the pathological lesion, for obstruction alone would be unlikely to be responsible for such a change in the blood picture. The local inflammatory reaction, as shown by microscopic examination of the gall bladder, was of a mild degree, probably less than might reasonably have been expected in view of the white cell count. However, there is no doubt that the general inflammatory reaction, as indicated by the leucocyte count, does not always bear a directly proportionate relationship to the amount of local reaction which may be present.

Because the microscopical findings showed only a mild degree of acute inflammation to be present, inflammatory exudate could have played but a minor rôle in augmenting the visceral contents and so leading to the increased tension which developed within the gall bladder. It is reasonable to assume, therefore, that this feature was chiefly due to the transudation of fluid into the lumen consequent upon the compressions of the blood vessels in the wall by muscular spasms. In support of this assumption the agony suffered by the patient bore testimony to the intensity of the muscular spasms of the gall-bladder wall, and he experienced so little relief in between the colic-like exacerbations that it seems probable that the musculature had passed into a state of tonic spasm upon which clonic spasms were superimposed from time to time. The corresponding severity of the vascular compression could readily have resulted in copious transudation of fluid from the congested submucosal and mucosal veins and capillaries.

As Rutherford Morison pointed out many years ago, the more bile the gall bladder contains when obstruction of its outlet occurs, the more rapid will be the progress of the pathological changes which follow, as a correspondingly smaller amount of exudate or transudate will be sufficient to increase the intravisceral tension to an abnormal degree. The rapidly progressive character of the pathological changes in the present case, indicating that the whole thickness of the wall would soon have become gangrenous had this termination not been forestalled by operation undertaken only 24 hours after the onset of the attack, supports Morison's contention, since the fluid found in the gall bladder at the time of operation was frankly bilious, however much its original appearance or physical characters might have been altered by exudate or transudate from the mucosa, a fact indicating that much bile was already present in the gall bladder when obstruction occurred, for no bile could have entered it from the common duct once this had taken place.

While the writer considers cholecystectomy preferable when operating upon a patient with acute obstructive cholecystitis if this procedure is not contraindicated by the presence of some general or local condition, yet it should be remembered that the danger attending the presence of increased intravisceral tension can be averted through relief of this tension by cholecystostomy (this procedure imitating Nature's drastic and dangerous method of relieving it by perforation through a gangrenous area), and this comparatively simple operation is here warmly commended to any inexperienced surgeon into whose hands one of these patients should chance to fall—as is bound to happen from time to time. The operation of cholecystectomy is fraught with many potentialities for serious difficulties, and,

until a surgeon is sufficiently skilled and experienced to accept such responsibility, it should always be done under the supervision of a senior surgeon. To arrange for the presence of such a supervisor is not always possible and in his absence the surgeon who has not yet reached this state of operative proficiency would, under these circumstances, be well advised to remember that a living patient with a drained gall bladder is infinitely preferable to a dead one with that viscus removed.

CASE 2. Mr. W. L. S., aged 57 years. This patient was first seen at his home on March 29, 1941, suffering from an attack of biliary colic. The only sign of note was a tenderness over the gall-bladder area, the temperature and pulse being normal. He gave a history of having had a somewhat similar, though milder, attack only once previously and that about 6 weeks before. His digestion had always been good except for occasional flatulence which had never caused him sufficient distress to seek medical advice. He had never been jaundiced. Under conservative treatment of rest in bed, an ice bag to the gall-bladder region, a fluid diet and control of pain by opiates, the attack subsided, the acute pain disappearing within a few hours and leaving in its wake the usual soreness in the right upper quadrant. By April 1 he was feeling quite fit again. On April 3 he was again stricken by biliary colic and when seen he appeared to be having a more severe attack than that from which he had suffered a few days previously. In addition to a marked tenderness over the gall-bladder area some rigidity of the abdominal musculature in this region had made its appearance. No mass was present. The temperature was 99 degrees F. and the pulse 84. He was advised to enter the Cottage Hospital for observation. On admission some 2 hours later his temperature was found to be 98 degrees F., pulse 88, the urinalysis was normal, but the leucocyte count was 20,000 with 83 per cent polymorphonuclears. Later in the day his temperature rose to 101.4 degrees F. and his pulse to 100. At this time he was actually feeling better, for the severe pain had passed off and examination of the abdomen revealed less tenderness and rigidity than when first seen earlier in the day and no abdominal mass was present. He had a good night and by morning his temperature had fallen to 98.4 degrees F. and his pulse to 80, while his leucocyte count had fallen to 15,150 with 66 per cent polymorphonuclears. By the third day after admission all signs and symptoms had disappeared and he was feeling well. Cholecystography the following day revealed a poorly functioning gall bladder containing stones. When the patient was told of these findings and informed that operation would be necessary at some convenient future date for the cure of the condition, he wished, for economic reasons, to have the operation performed as soon as possible. It was undertaken on April 8, under general anesthesia, the peritoneal cavity being opened through a Kocher subcostal incision. The wall of the gall bladder was thickened, edematous, and reddish in color and, although the viscus was distended, it was not tense. Several old, string-like omental adhesions were present, but the omentum itself, although lying in close proximity to the gall bladder, was normal in appearance and was making no attempt to envelop that viscus. Edema was also present around the cystic and common ducts. The common duct was not dilated nor was its wall thickened and so there appeared no indication for opening it. Cholecystectomy was performed and the gall bladder was found to contain multiple small, facetted calculi of the mixed type. The patient had an uninterrupted convalescence.

Microscopic examination showed a diffuse edema of all coats. A feature of the histological picture was the large number of mononuclear cells which were present throughout all layers but most abundant in the submucosa. In this layer numerous polymorphonuclear leucocytes were also to be seen.

This case was chosen as representative of the type in which the indications for operation, as outlined previously, did not develop during the attack and it was therefore unnecessary to operate at that time. In this respect it forms a distinct contrast to the first. The important point, however, is although operation in each of these two cases was undertaken at different stages of the disease, both patients were dealt with according to the principles of the rational treatment so that the time of operation in each case was decided essentially upon a knowledge of the pathology and its correlation with the symptomatology.

When the provisional diagnosis of acute obstructive cholecystitis was made on the history of biliary colic and the physical signs of tenderness and rigidity over the gall-bladder region together with some increase in the pulse rate and temperature, the patient was sent to hospital for further observation. The white cell count taken shortly after admission was interesting as it was higher than that in Case 1 although clinically the patient was not nearly so ill—a fact to which reference will be made later.

Later during the day of admission, when the temperature rose to 101.4 degrees F. and the pulse rate to 100 beats per minute, any temporary progression of the pathological changes which these findings might have rep-

resented was not confirmed by clinical examination, for both the tenderness and rigidity were less marked and the pain had diminished. Realizing that this clinical improvement might have been due to the opiates administered, the effect of which was to mask a progression of the pathological process, *the absence of a palpable mass at this time* nevertheless led to the conclusion that even if the lesion was progressive it had not yet reached the stage when an immediate operation was to be regarded as necessary to relieve increased intravisceral tension, in other words, the disease was still in the stage from which spontaneous recovery takes place in the majority of cases and we could rest secure in the knowledge that the patient's clinical manifestations were not perpetrating a costly deception upon us. The following morning, by which time any effect of the opiates upon the clinical manifestations could be disregarded, all signs and symptoms showed improvement (including a drop in the number of leucocytes to 15,000) unmistakably pointing to a retrogression of the pathological changes. This favorable course continued and the patient soon became completely free from symptoms. Thus the indications for immediate operation which sometimes develop in acute obstructive cholecystitis, and for which we must always watch carefully, did not appear, so that the question of such an operation did not arise in this case.

The surgical intervention necessary for the ultimate cure of the condition would have been delayed for a greater length of time than it was, to allow of a maximal retrogression of the pathological changes in the gall bladder, had it not been for the express wish of the patient to have it done as quickly as possible while he was still in hospital. Performed when it was, the operation provided an interesting opportunity for proving the correctness of deductions, and decisions made consequent thereon, prior to operation in the light of the principles governing the rational treatment. In the first place, the edematous and thickened wall of the gall bladder confirmed our opinion of pathological changes in this viscus as having been the cause of the patient's illness, but the clinical disappearance of symptoms, associated with the finding at operation of a passive, noninflamed omentum lying adjacent to the gall bladder, led one to conclude that these pathological changes were then in a process of retrogression, although sufficient time had not yet elapsed to allow of its completion. This opinion was confirmed later by microscopical examination of the excised gall bladder. However, the most striking feature about the viscus was that, though distended, it was not tense, indicating that there was no obstruction preventing the escape of its contents through the cystic duct. That obstruction *was* present in the early part of the attack we know, for the biliary colic which the patient experienced was the result of Nature's effort to overcome or remove it. Thus one deduction to be drawn from the pathological process as it presented itself at operation, and corroborating that made on the clinical findings prior to this event, is that the obstruction was relieved by natural means before the stage was reached that pathologically results in enlargement and tense distention of the gall bladder and that clinically is indicated by the development of the palpable mass which constitutes the most important indication for immediate operation to relieve the increased intravisceral tension and so avert the more serious terminations of the disease. The question naturally arises: did the gall bladder reach this stage but could not be detected on palpation? Had it done so, then the progression of the pathological changes which the attainment of this stage implies would certainly have given rise to the development of other increasingly severe signs and symptoms such as increasing rigidity, a continuous increase in the pulse rate and a deterioration of the patient's general condition, none of which, however, made its appearance. It might be stated here that no doubt there are some cases in which the gall bladder is situated so entirely under the liver that even when it has reached the stage of gross enlargement here referred to its fundal portion does not project sufficiently beyond the liver margin to be detectable on palpation. In such cases, however, a mass will still make its appearance and, although due to the omentum enveloping the gall bladder in its endeavor to exclude this pathological viscus from the general peritoneal cavity, yet its

presence at once gives valuable information concerning the condition of the gall bladder, for it will be unlikely to develop unless the pathological changes in this organ have already reached the dangerous stage of gross enlargement with acutely increased intravisceral tension. Moreover, in such cases this mass will usually appear in time to allow of the more serious terminations of the disease to be averted by surgical intervention, provided its development is correctly interpreted as indicating the advisability of such treatment.

Microscopic examination of the gall bladder showed the presence of a resolving acute inflammation (as indicated by the infiltration of large mononuclear cells) but enough evidence of the acute reaction was still present to indicate first, that it must have been quite marked early in the attack and, in addition, that the inflammatory element was definitely more predominant in this case than in Case 1. Yet the first patient, with the milder inflammatory changes in the gall bladder, rapidly became very ill and had to be operated upon as an emergency measure, while the second in whom these changes were more marked recovered spontaneously from his attack. What factor, then, determined an outcome in each case contrary to that which could reasonably have been expected if inflammation, *per se*, could have decided the issue? The answer to this question is, *obstruction of the outlet of the gall bladder*. We know that in both cases obstruction occurred, for each was the subject of biliary colic which, as mentioned previously, is caused by the forcible contractions of the smooth muscle in the gall-bladder wall and constitutes Nature's method of trying to overcome obstruction in a hollow muscular viscus, *but the essential difference between the 2 cases is that in the first the obstruction persisted while in the second it was relieved early by natural means*. The outcome in the first case was that the intravisceral tension rapidly increased and interfered so quickly with the blood supply to the gall bladder that gangrene of the mucosa had already occurred when operation was undertaken only 24 hours after the onset of the attack; in the second, the natural relief of the obstruction (as indicated by the cessation of colic) permitted the escape of exudate and transudate, poured out from the mucosa into the lumen, through the cystic duct, thus averting the danger, so well exemplified in the first case, of increased intravisceral tension and its serious consequences, and the patient recovered from the attack without surgical intervention having become necessary. These two representative cases illustrate well not only the importance of obstruction of the outlet of the gall bladder as a factor in determining the outcome of the disease but indicate also that, in the absence of obstruction, the inflammatory element is of minor importance as it is unlikely to terminate seriously. It was this important rôle played by obstruction that led the writer to suggest "acute obstructive cholecystitis" as the most suitable designation for the condition under consideration and he would like to state that at the time when he made this suggestion he was unaware that Mentzer had already done likewise in 1936 and thus inadvertently failed to acknowledge that author's priority in this matter. The paucity of references to the condition by this name subsequent to that date would appear to indicate that Mentzer's suggestion unfortunately was not received with any degree of enthusiasm for, as well as being correct terminology, it also serves the additional purpose of forcefully reminding the surgeon of this factor which is of such great importance in the etiology and prognosis of the disease.

OBSERVATIONS FROM STUDY

It is hoped that the presentation and discussion of these 2 cases have not only achieved their aim of illustrating the practical application of the principles of the rational treatment but have also shown that the correlation of the symptomatology with the pathology is a *sine qua non* if this application is to be carried out successfully. At this point, therefore, the writer wishes to draw attention to the fact that there have appeared in the literature from time to time articles describing cases in which advanced disease was found at operation while the clinical manifestations were minimal or even absent, the result of such reports being to promote the belief that the degree of the pathological process present in acute obstructive cholecystitis often bears no

direct relation to the symptomatology. Heuer, for example, states: "A study of the relationship between the clinical symptoms of acute cholecystitis and the pathologic course of the inflammatory process in the gall bladder shows that there is no direct parallelism between them—in other words, that the clinical symptoms exhibited by the patient do not give any certain indications of the course of the pathologic process in the gall bladder—whether this be toward restitution or toward gangrene and perforation." This belief, accepted apparently as it is by many surgeons, is responsible for much of the confusion which exists at the present time regarding the treatment of this condition, for if this belief were correct, it would naturally be impossible to know what are the clinical manifestations which indicate that operation should be performed if the progression of the disease to its more serious terminations is to be prevented, with the result that we would have no means by which to determine whether or not, or when, it should be undertaken to accomplish this purpose. But this confusion should not exist for it is based upon a wrong premise since, as illustrated in particular by these 2 representative cases, a very distinct parallelism usually does exist between the pathology and the symptomatology and, because this is so, the clinical manifestations which indicate the need for operation are definite and recognizable and have already been described by the writer. However, it is obvious that this parallelism can only be discerned if the pathological process is understood and, conversely, failure to discern it implies a lack of this understanding.

It has been the humbling experience of the writer on occasions to find that reconsideration of a mistaken diagnosis has proved this to be due either to ignorance of the underlying lesion or the symptomatology or to failure or lack of care to have observed or evaluated properly one or more clinical manifestations. He believes that similar shortcomings on the part of others are largely responsible for the placing in the "atypical" category of many of the cases of acute cholecystitis reported as such.

Where such cases as these have been reported, there do not seem to have been any attempts made to explain what are considered to be discrepancies between the extent of the pathological changes and the symptomatology. In fact the attitude usually adopted has been to regard them as inexplicable vagaries of Nature. However, the writer believes that, in many cases, they are more apparent than real and offers the following discussion in support of his opinion.

The gall bladder is a hollow muscular viscus and sudden obstruction of its outlet is the stimulus which causes its unstriated muscle to contract forcibly in an effort to overcome the obstruction, these forcible contractions of the unstriated muscle giving rise to biliary colic. Should the obstruction be relieved as, for example, by the extrusion of a stone into the common duct or by its falling back into the gall-bladder cavity, the stimulus causing these forcible contractions is removed and they will cease, no further clinical manifestations making their appearance. If, on the other hand, the obstruction is not relieved, then after a prolonged and intense effort over a variable period, exhaustion of the muscular walls will follow, the violent spasmodic contractions abate, and relief from the severe pain results, and *this in spite of the fact that the gall bladder is still obstructed.* When acute inflammation is superadded to such an obstructed gall bladder, then the intravisceral tension begins to increase, bringing in its train the pathological changes which have already been described. Hence there can be a stage in acute obstructive cholecystitis in which the classical severe pain is absent and the patient consequently feels better, *yet the pathology is progressive.* This stage may last for hours or days before gangrene finally supervenes, depending upon the rapidity of increase of the intravisceral tension, but during this time *the distended gall bladder will become palpable* (if it has not already done so before the cessation of the pain) and thus indicate clearly the progressive nature of the pathological process. *That such a stage can exist is a further cogent reason for advising operation without delay once the gall bladder has become palpable.*

When gangrene occurs, the nerves in the wall of the gall bladder share this fate along with the other tissues. "Dead men tell no

tales" and with the pain reflex-arc thus destroyed a period of delusion may follow, when the patient feels much better and at this time the surgeon may be deceived into believing that a retrogression of the pathological process has occurred. The same is true of the appendix, and there must be many surgeons who have encountered the deceptive lull in the symptoms, accompanied by return of a feeling of well-being, which often precedes the severe pain heralding the onset of perforation of a gangrenous appendix, *although in the case of the gall bladder the presence of a palpable, and therefore pathological, viscus should act as a deterrent against this deception.* When the gall bladder is the viscus affected, this lull is often of much longer duration because its edematous walls are much thicker so that perforation does not occur so readily, and the additional time thus given the omentum to play its rôle of abdominal policeman enables it to form a more efficient barrier against a free perforation into the peritoneal cavity. The writer is of the opinion that in acute obstructive cholecystitis the occurrence of gangrene in the absence of a markedly increased intravisceral tension, as indicated by a palpable gall bladder, must be exceedingly rare and he has never seen a case of gangrene except in its presence. Intramural infection alone is unlikely to be diffuse or severe enough to produce it.

Mention is sometimes made of unusual cases in that the presence of a palpable gall bladder, found at operation to be the seat of advanced acute cholecystitis, was unaccompanied by rigidity of the overlying musculature. We know that such rigidity represents the reaction of the abdominal muscles to irritation of the parietal peritoneum and in such a case, therefore, its absence can only be explained by protection of the parietal peritoneum from contact with the inflamed serosa of the gall bladder. The agent responsible for this is the omentum, *which will be found enveloping the gall bladder in all such cases*, the inflammatory process involving its inner surface in contact with the gall bladder not having yet spread by continuity of tissue through its substance to involve its outer surface in contact with the parietal peritoneum. (However if and when its outer surface does become involved, then the parietal peritoneum will become irritated by contiguity and rigidity of the overlying muscles will make its appearance.) In such a case, then, the pathological process can be progressive although there is no rigidity of the overlying muscles, but *against the guide to the pathological situation is the palpable mass*, the significance of which is in no way altered by the fact that rigidity is absent.

While it is not claimed that the above considerations entirely solve the problem of the "atypical" case of acute obstructive cholecystitis, that is, one in which a lack of relationship appears to exist between the pathology and the symptomatology, yet it is felt that if many of such cases were restudied in the light of these considerations, this relationship would readily become evident. They also indicate how the development of a palpable mass in the right upper quadrant, if only its pathological significance is understood, will often provide the solution to what may appear, in the event of failure to interpret its significance correctly, to be a perplexing clinical problem. *Too much emphasis cannot be laid on the fact that in this disease the significance of this palpable mass remains unaltered no matter to what extent apparent lack of confirmation by other signs and symptoms may seem to deny its import.* Consequently it is felt that this finding should be regarded as the most important single clinical manifestation in acute obstructive cholecystitis.

The writer, therefore, feels that any surgeon, armed with the knowledge of the pathology and symptomatology of acute obstructive cholecystitis, cannot but disagree with the statement, encountered repeatedly in the literature, that these two aspects of the disease often bear no direct relationship to one another. It is unfortunate that this statement, by having been allowed to pass so long unchallenged, has gained such wide acceptance, since it is not only misleading but no less to be deplored than this is the adverse influence which such teaching cannot fail to exert upon the thinking of the young surgeon who, in striving to reach some conclusions about this disease, already finds himself confused by the diversity of advice offered him in the litera-

ture, for it contains the erroneous implication that any attempt to outline a rational treatment is foredoomed to failure and in addition tends to discourage him still further by giving the impression, as perturbing as it is incorrect, that the subject is one beset with insurmountable difficulties.

SUMMARY

1. The pathology of acute obstructive cholecystitis and the principles governing the rational treatment of this condition are described briefly.

2. Two representative cases of this disease are presented and discussed in order to (a) illustrate the practical application of these principles to the individual case and (b) show how a knowledge of the pathological process enables the observer to correlate it with the symptomatology and thus to follow clearly the progress of a case.

3. Attention is directed to the statement, often encountered in the literature, that in this disease there is often no direct relationship between the pathology and the symptomatology. Certain points are discussed to show that in many cases such discrepancies as may appear to exist between these two aspects of the disease are readily capable of explanation. Consequently, this statement is considered erroneous and mention is made of its harmful effect upon the surgical teaching of this disease.

4. The importance of the development of a tender, palpable mass in the right upper quadrant of the abdomen during the course of the disease is again emphasized, for the crucial significance of this clinical sign remains unaltered no matter to what extent apparent lack of confirmation by other signs and symptoms may seem to deny its import.

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CHANGES IN EXTRACELLULAR WATER AT DELIVERY AND IN THE PUERPERIUM

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IT is well known that normal pregnancy is accompanied by a progressive gain in weight of the mother which is two to three times greater than can be accounted for by the growth of the conception product. When this total weight gain is less than 20 to 25 pounds, the mother usually returns to her pre-pregnancy weight early in the puerperium (Waters). Associated with this puerperal weight loss there is characteristically a diuresis. This has led to the inference that in pregnancy there has occurred a hydration of the maternal tissues, and that after delivery this water is mobilized and excreted.

In a previous paper (3) we have shown that normal pregnant women do gain an average of 9 to 10 pounds of extracellular water, exclusive of that in the conception product. Individual cases varied widely, and under salt restriction the changes in volume of extracellular water were markedly affected.

In the present study we have determined the changes occurring in the volume of extracellular water during delivery and the puerperium, and correlated these changes with changes in body weight. Incidentally we have made observations on the distribution of thiocyanate as between maternal serum on one hand, and cord serum, amniotic fluid, placental tissue, and milk on the other.

MATERIAL AND METHODS

We have described elsewhere (6) the details and limitations of our measurements in pregnancy of thiocyanate-available water (roughly equivalent to extracellular water). Briefly, on the assumptions that sodium thiocyanate is confined to, and evenly distributed in, extracellular water, one can calculate the volume of that water by dividing the serum concentration of thiocyanate into the amount of thiocyanate in the body.

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In measuring the thiocyanate-available water, in the present study, we proceeded as follows. Normal patients in early labor and with intact membranes were weighed and given 1000 milligrams of sodium thiocyanate intravenously. All urine was saved until the time of delivery, in order to determine the renal excretory loss of thiocyanate. Immediately postpartum (minutes) a blood sample was taken for analysis, and a second 1000 milligrams of sodium thiocyanate was injected. Four hours later a second blood sample was taken, and the postpartum urine collection ended. On the 6th and 10th days postpartum the patients were weighed, and the measurements were repeated. The determination of available water was usually repeated again at 6 weeks postpartum. On all of these occasions, blank blood samples were taken before the injection of the 1000 milligrams of sodium thiocyanate, and blank urines were collected over a known period of time prior to the test. Four hours after the thiocyanate injection, except for the antepartum measurement, blood samples were taken and urine collections were ended.

All of the amniotic fluid was caught and measured, and the concentration and quantity of thiocyanate therein was determined. The blood loss was measured, and the fetus, placenta, and membranes were weighed. The concentration of thiocyanate was determined in the cord blood and in the placental tissue. The last named measurement was paralleled by the determination of the total water concentration of the placenta (by exsiccation).

In the placental analyses, the cord and sac membranes were removed, the stagnant blood was gently pressed out of the large veins, and the placental surfaces were sponged dry. The placenta was then cut, pie-wise, into thirty-seconds. Every fourth sector was taken for the water and thiocyanate determinations. The membranes were stripped off and the

pieces were finely minced together with scissors and then ground with a mortar and pestle. Total water was determined by spreading out weighed quantities of ground tissue in thin layers on watch glasses, and then drying to constant weight at a temperature of about 90 degrees C. For thiocyanate determination, ground tissue was extracted for 24 hours with nine times its weight of 0.9 per cent aqueous sodium chloride. Proteins were then precipitated with 50 per cent trichloroacetic acid added in a 1:1 ratio (by volume). Thiocyanate was then determined in the filtrate.

The tests were not completed if the patient delivered in less than 4 hours or more than 24 hours after the initial thiocyanate injection. We excluded patients showing blood pressure elevations at any time, or developing febrile morbidity. In some cases patients were excluded because they received infusions. When accurate collections of amniotic fluid and blood loss were not made, the tests were discarded. Also, patients having abnormal deliveries were excluded. Anesthesia was minimal, and usually consisted of gas and oxygen, often with ether. In order to fulfill all of these conditions, we were able to finish the tests on only about one-fourth of the cases begun. In all, complete studies were made in 16 patients. In an additional 14 patients we measured the puerperal losses of water, by determining the extracellular water immediately after delivery and again at 6 days and at 6 weeks postpartum.

Thiocyanate was determined in duplicate in serum, urine, amniotic fluid, milk, and placental filtrates by a photoelectric method described elsewhere (4). Colorless crystal clear filtrates were made from urine, amniotic fluid, and milk by adding an equal volume of 10 per cent sodium tungstate solution containing about 5 per cent of serum protein, followed by eight volumes of twelfth normal sulfuric acid.

Calculations. In the first measurement of available water, the serum concentration of thiocyanate was divided into the quantity of thiocyanate left in the body (initial 1000 milligrams minus the urinary loss). Thus in addition to the mother's extracellular water, the antepartum measurement includes: (1) the available water of the fetus and placenta, and (2) a variable amount of amniotic fluid depending upon (a) the time elapsed from the thiocyanate injection to delivery, and (b) the volume of amniotic fluid.

In subsequent measurements of available water, the calculation was somewhat more complicated. The urinary loss of thiocyanate residual from previous tests was determined over a 4 hour period just before the new injection. This loss was assumed to continue in the same magnitude during the 4 hours after the new injection, and was subtracted from the total thiocyanate loss during that period. Thiocyanate was determined in the blank serum taken just before the injection, and again in the serum taken 4 hours later. The rise in serum thiocyanate was then divided into (1000 milligrams minus corrected urinary loss of thiocyanate). Serum thiocyanate was determined in both the blank and the test sera independently, and the *rise* was checked by using the blank to obtain the "center setting" for the Evelyn photoelectric colorimeter, and by reading the test serum directly. These two ways of measuring the rise in serum thiocyanate always checked very closely.

RESULTS

The data for the first 16 cases are summarized in Table I. It will be seen that the major decreases in weight and in available water occur at delivery, and in the first 6 days postpartum. (Case 6 does not conform to the rule, in that she lost no water in the early puerperium. However, she had been on a low salt diet for more than a month before delivery.) From the 6th to the 10th days postpartum, the weight drops only slightly, while the available water remains essentially unchanged. The changes between the 10th day and 6th week postpartum are variable, but in all cases, further loss of water does occur. There seems to be no correlation between the total weight gain in pregnancy and the water and weight loss in the puerperium. This is to be expected, since all but one of the patients had normal proportions of available water antepartum; the one exception (Case 4) had an extracellular water volume only slightly above the upper limits of normal.

TABLE I.—THE CHANGES IN WEIGHT AND IN AVAILABLE WATER DURING DELIVERY AND THE PUERPERIUM

Case Age Para	Weight in pounds			Available water, in liters					Weight, in kilograms				
	Before pregnancy	p.p. 10 days	Gain in pregnancy	a.p. 0 days	p.p. 0 days	p.p. 6 days	p.p. 10 days	p.p. 6 wks.	a.p. 0 days	p.p. 0 days	p.p. 6 days	p.p. 10 days	p.p. 6 wks.
1 23 I	98	99.5	18	18.52	17.04	13.56	14.51		52.73	47.52	45.68	45.22	45.22
2 24 I	128	131.5	23	22.70	21.36		16.12	15.45	68.86	63.78	60.91	59.77	61.82
3 18 0	113	120.0	17	18.22	16.73	15.40	14.12	13.67	59.30	54.93	55.91	54.55	
4 21 0	134	135.5	21	26.90	24.50	19.25		16.87	70.65	65.85	61.59	61.59	60.23
5 19 I	110	117.0	20	19.40	18.50	15.16	15.43		50.31	55.83	53.41	53.18	
6 20 0	120	140.5	35	19.18	17.12	17.87	17.44	15.45	70.34	66.12	64.66	63.86	
7 15 0	108	107.0	13	18.98	18.10	16.20	16.82	15.22	55.22	51.02	48.64	48.64	49.54
8 22 III	108	119.7	27	18.84	18.07	15.72	16.17	14.02	61.59	56.84	55.45	54.43	56.82
9 18 0	134	153.0	34	24.03	22.77	19.45	19.97		76.36	71.44	69.32	69.55	
10 29 I	150	155.0	20	24.00	21.72	18.45	18.40	17.70	77.50	73.05	70.91	70.45	71.36
11 29 0	112	120.0	21	19.94	18.43	15.41	15.48	14.47	60.45	56.97	55.45	54.54	55.91
12 27 0	100	104.0	15	17.58	15.62	13.91		11.68	52.27	48.45	47.27	47.27	44.55
13 21 0	115	132.5	34	22.12	19.30	16.66	16.36	14.92	67.73	61.88	60.23	60.23	59.09
14 27 0	100	98.5	15	18.16	16.48	14.14		11.77	52.39	48.45	46.02	44.77	42.96
15 29 III	103	116.0	34	20.48	17.95	15.02		13.87	62.16	55.51	52.73	52.73	
16 18 0	128	135.7	26	22.69	20.51	18.15	17.82	16.38	70.00	64.57	61.36	61.70	61.36

A. p., antepartum, p. p., postpartum.

The loss of available water at delivery. A detailed analysis of the delivery loss of available water is presented in Table II, without taking account of water of transpiration. We arrived at the "calculated loss of available water" (columns 2, 3, 4, 5 and 6 of Table II) from the following considerations. When available water is calculated, one divides the serum concentration of thiocyanate into the quantity of injected thiocyanate remaining in the body at the time the serum sample is taken. If the concentration of thiocyanate in the water at any site is less than that of the serum, then not all of that water is included in the measurement. If, for instance, the concentration of thiocyanate in amniotic fluid is

TABLE II.—THE LOSS OF AVAILABLE WATER AT DELIVERY

Patient	Loss of available water at delivery, in ml.						Discrepancy: (calculated minus measured)		Weight lost at delivery, kgm.	% of delivery weight loss as available water
	Calculated loss of available water					Difference, (a.p.-p.p.) measurements	ml.	% of a.p. vol.		
	Amniotic fluid	Blood loss	Placenta	Fetus	Total					
1	341	83	382	983	1790	1480	—310	—1.67	5.21	34.1
2	524	99	390	1015	2030	1350	—680	—2.99	5.08	39.7
3	0	83	465	884	1430	1500	70	0.38	4.37	32.5
4	301	165	438	1000	1900	2400	500	1.86	4.80	39.3
5	228	124	285	692	1330	910	—420	—2.16	3.48	38.0
6	460	165	326	760	1710	2060	350	1.82	4.22	40.2
7	277	41	334	836	1490	880	—610	—3.21	4.20	35.3
8	477	20	390	910	1800	770	—1030	—5.47	4.75	37.7
9	207	165	504	938	1810	1260	—550	—2.29	4.98	36.1
10	488	41	465	803	1800	2280	480	2.00	4.45	40.2
11	98	194	234	816	1340	1510	170	0.85	3.48	38.2
12	140	124	319	796	1380	1960	580	3.30	3.82	35.9
13	370	331	514	995	2210	2820	610	2.76	5.85	37.5
14	337	124	358	802	1620	1680	60	0.33	3.94	40.8
15	398	83	608	1085	2170	2530	360	1.76	6.65	32.4
16	614	41	456	1 15	2130	2180	50	0.22	5.43	39.0
Av.	329	118	404	896	1740	1730	—10	—0.05	4.67	37.0

45 per cent of the concentration in the maternal serum, then 45 per cent of the amniotic fluid volume is included in the antepartum measurement of available water; i.e. the volume of amniotic fluid is multiplied by the ratio

$$\frac{\text{concentration of thiocyanate in amniotic fluid}}{\text{concentration of thiocyanate in maternal serum}}.$$

The available water of the placenta was calculated in the same way, from analyses of the thiocyanate concentration in placental tissue. The blood loss at delivery was multiplied by 0.827 to obtain the available water loss. (Oberst and Plass found that the water content of the whole blood in late pregnancy averages 82.7 per cent. All of the blood water, intracellular as well as extracellular, is available to thiocyanate according to Crandall and Anderson.) The available water of the fetus was assumed to be 30 per cent of the body weight; this assumed volume was corrected by multiplying with the ratio

$$\frac{\text{concentration of thiocyanate in cord serum}}{\text{concentration of thiocyanate in maternal serum}}.$$

The calculated loss of available water at delivery averages 1.74 liters (3.80 pounds), which represents 37.0 per cent of the average weight loss of 10.3 pounds. In individual cases, the calculated loss often does not check very closely with the loss as determined by difference between antepartum and postpartum measurements. We are of the opinion, however, that the calculated loss may be the more reliable because errors of several hundred milliliters could result from small percentage errors in the measurement of available water volumes averaging 21,000 milliliters. In column 8 of Table II we have presented the discrepancies between the calculated and measured losses in available water. When these discrepancies are related to the total volumes measured, the percentage is seen to be small enough usually to fall within the range of error of the test (column 9).

The range of error in the determination is considered to be about ± 2.0 per cent. The chemical measurement of the thiocyanate is accurate within ± 1.0 per cent (4), or probably less since duplicate determinations were re-

TABLE III.—ANALYSIS OF DELIVERY AND PUERPERAL WATER LOSSES

Case	Total weight of water lost, pounds		Water lost at delivery		Water lost in first 6 days postpartum			Water lost between 6 days and 6 weeks postpartum			Ratio* of water loss to weight loss
	a.p. to 6 weeks p.p.	Puerperium only	Pounds	Per cent of total water loss	Pounds	Per cent of total water loss	Per cent of puerperal water loss	Pounds	Per cent of total water loss	Per cent of total water loss	
1			3.23		7.60						1.09
2	15.85	12.92	2.93	18.5	11.46	72.3	88.7	1.46	9.2	11.3	3.00
3	9.94	6.68	3.26	32.8	2.92	29.2	43.5	3.76	38.0	56.5	6.83
4	21.95	16.71	5.24	23.9	11.49	52.4	68.8	5.22	23.7	31.2	1:35
5			1.97		7.30						1.15
6	9.04	4.54	4.50	55.2	Gain (0.75)			5.29	64.7	145.0	
7	8.21	6.28	1.93	23.4	4.15	50.6	66.1	2.13	26.0	33.9	1.93
8	10.54	8.86	1.68	16.0	5.14	48.8	58.0	3.72	35.2	42.0	202.5
9			2.75		7.26						1.47
10	13.76	8.78	4.98	36.4	7.15	51.9	81.4	1.63	11.7	18.6	2.36
11	11.96	8.66	3.30	27.6	6.60	55.2	76.2	2.06	17.2	23.8	3.71
12	12.90	8.62	4.28	33.2	3.74	29.0	43.4	4.88	37.8	56.6	1.01
13	15.73	9.57	6.16	39.2	5.77	36.7	60.3	3.80	24.1	39.7	1.56
14	13.96	10.29	3.67	26.3	5.11	36.6	49.7	5.18	37.1	50.3	0.86
15	14.45	8.92	5.53	38.3	6.41	44.4	71.9	2.51	17.3	28.1	1.06
16	13.80	9.03	4.76	34.5	5.17	37.4	57.2	3.87	28.1	42.8	1.28
Av. of all			3.80		6.03						
Av. of complete cases	13.24	9.22	4.02	30.4	5.72	43.2	62.1	3.50	26.4	37.9	1.62

*Ratio calculated from last simultaneous measurements of weight and available water (see Table I).

quired to check within 0.04 milligrams per 100 milliliters. The injection of 20 milliliters of the thiocyanate certainly entails some error. An error of 1 per cent would allow a deviation of 0.2 milliliters in the volume injected.

The loss of available water postpartum. Tables III and IV summarize the puerperal loss of available water. As already mentioned, the major loss in weight and available water occurs in the first 6 days postpartum. This accords with Bray's study of puerperal weight loss.

It is interesting to compare the water loss with the weight loss (Table III) in the light of our previous suggestion (7) that normally, in late pregnancy, intracellular water may shift out into the extracellular spaces. As Table III shows the weight of available water lost is greater than can be accounted for by the weight loss. This would suggest that some of the water is still in the body, but is no longer available to thiocyanate; i.e. some of the water may have re-entered the cells.

The average weight of water lost from just after delivery to the 6th day postpartum averages 5.02 pounds. Bray has analyzed the puerperal weight loss day by day in 64 women. By the 6th day postpartum the average weight loss was about 2.6 kilograms. If we assume the same proportionality between weight loss and available water loss (1:1.28) as found in our patients, the average weight of water lost would be 7.3 pounds in Bray's patients as compared with 5.02 pounds in ours. If the same calculation is applied to the data of Stander and Pastore who found an average weight loss of 2.3 kilograms in the first 10 days postpartum, the water loss is found to be 6.5 pounds.

From the 6th to 10th days postpartum, the changes in extracellular water were insignificant.

TABLE IV.—PUERPERAL LOSSES OF EXTRACELLULAR WATER IN SECOND SERIES OF PATIENTS

Cases Age Para	Weight in pounds			Puerperal water loss				
				Total pounds	First 6 days		Sixth day to 6 weeks	
	Before pregnancy	Postpartum 6 days	Gain in pregnancy		Pounds	Per cent of total	Pounds	Per cent of total
17 18 I	145	150	25	7.12	0.72	10.2	6.40	89.8
18 20 II	180	169	7	7.26	6.32	87.1	0.94	12.9
19 22 I	125	133	25	3.24	4.29		Gain 1.05	
20 32 V	196	198	20	14.52	12.36	85.1	2.16	14.9
21 26 I	149	146	23	13.17	4.53	34.4	8.64	65.6
22 24 I	128	134	18	Gain 0.39	Gain 2.62		2.23	
23 19 I	118	115	11	5.95	4.70	79.0	1.25	21.0
24 25 I	103	113	22	9.83	5.80	59.0	4.03	41.0
25 29 IV	134	140	23	6.86	1.18	17.2	5.68	82.8
26 19 I	135	136	17	4.47	2.63	58.8	1.84	41.2
27 21 II	141	152	20	5.27	2.80	53.2	2.47	46.8
28 20 I	121	130	23	4.64	5.03		Gain 0.39	
29 19 I	104	106	21	10.31	8.60	83.4	1.71	16.6
30 30 III	132	140	21	11.72	4.62	39.4	7.10	60.6
Av.				7.43	4.35	58.6	3.08	41.4
Grand av., tables III & IV				8.30	5.02	60.5	3.28	39.5

From the 10th day to the 6th week postpartum, all but 2 of 27 patients lost extracellular water, often in the face of small gains in body weight. (Since many of the 6 weeks tests were done in the patients' homes, we do not have all of their weights for this time.)

The average weight of extracellular water lost between the 6th day and the 6th week postpartum was 3.28 pounds, or 39.5 per cent of that lost after delivery, and about 26 per cent of the total water loss from just antepartum to 6 weeks postpartum.

The distribution of thiocyanate between maternal blood and the conception product. (1.) *Cord serum-maternal serum.* The concentration of thiocyanate in cord serum was always less than that in maternal serum. The proportion ranged from 82.3 to 99.4 per cent, and averaged 90.1 per cent; all but 4 values fell between 86 and 95 per cent. This accords with the work of Lavietes and associates, who compared the concentration of thiocyanate in serum with the concentration in effusions and edema fluid. They found that in the effusion fluid the concentration of thiocyanate averaged 90 per cent of that in serum, with the proportion ranging from 70 to 95 per cent (or excluding two extreme cases, the range was 86 to 93 per cent). They made ultrafiltrates of serum, *in vitro*, and found that the concentration of thiocyanate in the ultrafiltrates was less than that in serum by about the same proportionality. They therefore suggested that part of the thiocyanate was "bound" in the serum (plasma). In a later paper, Rosenbaum and Lavietes adduced evidence for the existence of a lipoid-thiocyanate complex in plasma and serum. Such a complex would prevent the free diffusion of thiocyanate and therefore (together with the Donnan effect) would prevent the establishment of equal concentrations of thiocyanate in serum (or plasma) and their ultrafiltrates *in vivo* or *in vitro*. Apparently this lipoid-thiocyanate complex prevents the establishment of equal concentrations of thiocyanate on both sides of the placenta.

2. *Placental tissue-maternal serum.* The concentration of thiocyanate in placental tissue ranged from 71.5 to 79.2 per cent of the concentration in the maternal serum (excluding one case in which the proportion was unaccountably low at 59.9 per cent). The average proportion was 76.0 per cent.

The total water content of the placenta was very consistent from case to case, the range being 81.91 to 83.12 per cent (none excluded).

Assuming that all of the placental thiocyanate is distributed in the placental water, we find that the concentration would average 92 per cent of that in the maternal serum. It would appear, therefore, that thiocyanate freely enters the cells of the placenta, and that all placental water is "available" to thiocyanate.

3. Amniotic fluid-maternal serum. The amniotic fluid thiocyanate concentration rises progressively with time, as Figure 1 shows. While we do not have enough cases to decide, it appears that larger volumes of amniotic fluid show somewhat slower rises in thiocyanate concentration (reasonably enough).

Flexner and Gellhorn have studied the rate of exchange of water and sodium between the maternal circulation and the amniotic fluid in the guinea pig. They found that the rate of water exchange was such that the amniotic fluid water might be completely replaced about once an hour, while the exchange of sodium went on at a rate fifty times slower. In our patients, the rate of entrance of thiocyanate into the amniotic fluid would be roughly comparable with the rate of sodium exchange in the guinea pig.

4. Breast milk-maternal serum. In 14 cases we have determined the ratio of thiocyanate concentration as between breast milk and maternal serum. These ratios varied from 0.06 to 0.24 except for one at 0.52. Two-thirds of the ratios fell between 0.14 and 0.19. In each patient the ratio was the same at 4 hours as at 24 hours after the thiocyanate injection, and was the same for milk taken before nursing as for that taken after. In those patients having determinations at 6 days and again at 10 days, there was no difference between the ratios on these days. We have no explanation for the relatively high ratio found in the 1 patient, who incidently was a poor milk producer.

ANALYSIS OF STUDY

In a study of the rate of gain in available (extracellular) water throughout normal pregnancy, we (3) concluded that the total volume increase averaged about 6.3 liters (13.7 pounds) with wide variations from case to case. Of this, we tentatively assigned 1500 to 2000

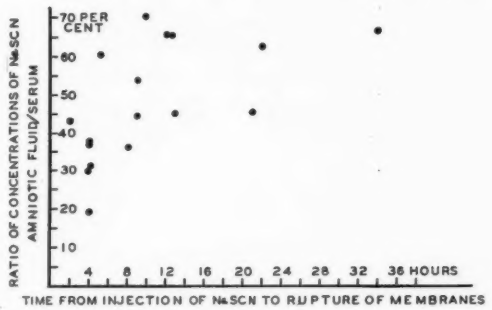

Fig. 1. The relation between thiocyanate concentrations in amniotic fluid and serum as a function of time elapsed from the injection of thiocyanate until the rupture of the membranes.

milliliters (3.3 to 4.4 pounds) to the conception product, leaving roughly 9 to 10½ pounds for the hydration of maternal tissues.

In general, the data of the present study are in accord with our previous conclusions. The total loss of available water from just before delivery to the 6th week postpartum averaged 6.06 liters (13.24 pounds), and of this an average of 1.74 liters was found in the amniotic fluid, placenta, and fetus (Tables II and III). Table III shows an average puerperal loss of 4.22 liters, or 9.22 pounds of extracellular water which had presumably contributed to the hydration of maternal tissues. However this average water loss is lowered by the inclusion of the additional patients shown in Table IV. For the combined series of 27 patients, in whom complete postpartum studies were made, the average puerperal loss of extracellular water becomes 3.85 liters, or 8.30 pounds. As was pointed out in the earlier study (3), there is a very wide variation from patient to patient in the amount of water gained during pregnancy (and lost postpartum). One of our patients (Case 22) actually gained extracellular water after delivery. However, she had been on a low salt diet for 4 months.

This average of 8.30 pounds of water of hydration falls a little short of our previous estimate, but as we pointed out in that paper, the weight loss which often precedes the onset of labor may be associated with the loss of some extracellular water. Evidence for this is seen in certain patients of a series reported

elsewhere (7). There were 11 patients in whom measurements of extracellular water had been made at the 36th to 37th week of gestation and again within a day or two before the onset of spontaneous labor. In all but 3 of these there had occurred a loss in water, and in 2 of the 3 exceptions the gains were very slight. Since the average rate of gain in available water, in the last 6 weeks of pregnancy, is about 210 milliliters per week, it would seem that these patients might have lost from 600 to 900 milliliters of water just before the onset of labor. Such a loss, added to the measured losses described in the present study, would balance nicely with the estimated gain previously described.

As is clear from Table III, the major loss of water in the puerperium occurs in the first 6 days. Indeed 60 per cent of the total puerperal loss occurs within this time. (Since we have not determined the available water after the 6th week postpartum, we are not certain whether further loss occurs.)

Our interest in measuring extracellular water in pregnancy was originally stimulated by a desire to separate the water-gainers from the protoplasm-gainers, among patients who had shown rapid or excessive weight increments (6). We were not certain that our measurements always did this, since the possibility of intracellular water retention could not be eliminated, and the test differentiated only between gain in *extracellular* water and gain in something else. The puerperal weight losses in the patients of the present series have some relevance for this question.

It seems improbable that water was retained, antepartum, in the cells of the normal patients who were used in the present study, unless such retention persisted beyond the 6th week postpartum. The basis for this statement is the fact that the weight of extracellular water lost in the puerperium was always greater than the loss in the body weight. This disparity suggests that postpartum the cells may gain water rather than lose it. This might mean that antepartum the cells had lost water to the extracellular space, a suggestion which we have previously offered (3, 7) as a possible explanation for certain observation made in late pregnancy.

We can account for most of the normal weight gain of 20 to 25 pounds in pregnancy, when we add the weight of extracellular water gained in the maternal tissues to the weight of the conception product. The fact that this added extracellular water is lost in the puerperium accounts for Waters' observation that patients with such normal weight gains usually return to their prepregnancy weights by the 6th week postpartum. Patients with larger weight gains may or may not return to their prepregnancy weights, depending upon what constitutes the excessive gain. When the excessive gain is water, that water is quickly lost after delivery. If the excessive gain is protoplasm, then the patient usually will not return to her initial weight. This is illustrated by Cases 6, 8, 9, 13, and 15 in the tables. These patients had normal proportions of available water, antepartum, and therefore their excessive weight gains were partly protoplasm which they still kept after the postpartum adjustment of the water balance.

It has long since been surmised that pregnant women do store water in their tissues, and the familiar and characteristic postpartum diuresis has been interpreted as evidence for such storage and for the early puerperal dissipation of the stored water. Crabtree, in a semiquantitative approach to the problem, compared the fluid intake with the urine volume output in puerperal women. He found negative water balances of considerable magnitude, which would have been still greater with the inclusion of the water of transpiration, of the milk, and of the lochial discharge. Taylor, Warner, and Welsh found a negative sodium balance in 3 postpartum women. The losses of sodium were 4.00, 4.08, and 6.59 grams in the first 10 days after delivery. Since potassium balances were not determined, it is not possible to calculate the volumes of extracellular water which were lost along with this sodium dissipation. However, the sodium loss does point to a loss of extracellular water, in volumes falling within the range we have described.

In assessing our measurements of extracellular water, we would say that they seem to confirm the clinical impressions that (1) maternal hydration does occur in pregnancy, and

(2) there is a rapid loss of the retained water in the puerperium. In addition, the measurements show (3) that most—if not all—of the water retained is extracellular, and (4) that most of the "normal" weight gain in pregnancy is accounted for by the conception product plus extracellular water.

Not all observers have agreed that hydration of the maternal tissues does occur in pregnancy. Freyberg, Reekie, and Folsome studied the water, sodium, and energy exchange during the latter part of pregnancy in a normal primigravida, and concluded that she had not retained more water than could be accounted for in her conception product. Also Beck, in his textbook, writes that most of the weight gain over and above that found in the conception product is attributable to maternal fat; he does concede that there may be some water retention however. Childs and Eichelberger, from analyses of muscle, found no indication of any increase in tissue water in the pregnant dog.

It is possible that the thiocyanate method for measuring extracellular water may give misleading results. Perhaps the cell permeability increases in late pregnancy, thus allowing the entry of the thiocyanate. If this should happen, then the apparent extracellular volume would include some intracellular water. However, if the thiocyanate ion enters such cells, it would seem that sodium and chloride ions might also do so, and the intracellular water included in the measurement would be *functionally* extracellular regardless of its location.

We prefer to accept the measurements of thiocyanate-available water at face value, for the increase during pregnancy and the recession postpartum are in accord with the clinical impressions which are mentioned in this study.

SUMMARY AND CONCLUSIONS

1. In a series of 16 normal patients, we have determined the changes occurring in the volume of thiocyanate-available water (extracellular water) during delivery and in the early and late puerperium. The puerperal water loss was measured in an additional series of 14 patients.

2. Incidental observations were made upon the distribution of thiocyanate as between maternal serum on one hand, and cord serum, amniotic fluid, placental tissue, and milk on the other.

3. The loss of available water at delivery averaged 1.74 liters, or 3.80 pounds. This can be accounted for in the fetus, placenta, amniotic fluid and maternal blood loss.

4. The major loss in available water usually occurred in the first 6 days postpartum. The average loss for this period was 2.30 liters, or 5.02 pounds.

5. The loss in available water between the 6th and 10th postpartum days was usually insignificant.

6. Between the 6th day and 6th week postpartum, all but 2 of 27 patients showed further losses in available water, often in the face of weight gains.

7. The total loss in available water, from just antepartum to 6 weeks postpartum, averaged 6.06 liters or 13.24 pounds in the 13 patients in whom the relevant measurements were made.

8. The total puerperal loss in available water, from just postpartum to 6 weeks later averaged 3.80 liters or 8.30 pounds in 27 patients. Presumably this quantity of water had contributed to the hydration of the maternal tissues during pregnancy.

9. The concentration of thiocyanate in cord serum averaged 90 per cent of that in maternal serum. The probable reason for this was discussed.

10. All of the placental water (making up 82.63 per cent of the placenta by weight) appeared to be available to thiocyanate. The concentration of thiocyanate in placental water averaged 92 per cent of that in maternal serum.

11. The concentration of thiocyanate in the amniotic fluid rose progressively toward the maternal serum concentration.

12. The concentration of thiocyanate in breast milk ranged from about 6 per cent to 52 per cent of the concentration in maternal serum. The concentration in milk taken before nursing was about the same as that taken after, apparently ruling out progressive passive diffusion of thiocyanate into the stored

milk. Equilibrium between maternal serum and milk was established within 4 hours.

13. It appears that most of the normal weight gain in pregnancy can be accounted for when the weight of the conception product and the weight of extracellular water gained in pregnancy (and lost in the puerperium) are added together. By "normal weight gain" we mean gains of 20 to 25 pounds in women who quickly return nearly to their prepregnancy weights.

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THORACIC INJURIES

Review of Cases

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IN the past wars thoracic injuries have been attended by high rates of mortality and morbidity. Prompt recognition of the seriousness of these wounds with restoration of normal cardiorespiratory physiology is essential because of the narrow margin of safety under which this system functions. In the last World War there were 4,595 cases of thoracic injuries among our casualties, with a mortality of 24.05 per cent (11). Duval collected a series of 3,453 cases of chest wounds in the last war by reports from 37 authors and found a general mortality of 20 per cent. Ransom, in quoting statistics for various wars since the Crimean has shown a progressively decreasing mortality rate in injuries of the chest. In the Crimean war the English lost 79.2 per cent; in the War between the States 62.6 per cent were lost; the Germans lost 56.7 per cent in the Franco-Prussian War; the British lost 27.5 per cent in the first World War; the Chinese have lost 14.8 per cent in the current Sino-Japanese conflict.

The principal considerations in the treatment of all chest injuries are, first, the treatment of shock; second, the restoration of normal cardiorespiratory physiology; and, third, the treatment of any complications or sequelae which may arise. It has been concluded that surgical intervention in the treatment of thoracic injuries is indicated in the presence of: (1) open, sucking wounds of the chest, (2) stab wounds of the heart, (3) compression or tension pneumothorax, (4) extensive subcutaneous emphysema, (5) severe hemorrhage from intercostal or internal mammary vessels, (6) large, lacerated wounds of the lung, (7) wound infections, and (8) empyema. Other conditions which must be watched for and treated as they arise are: traumatic asphyxia, "blast injuries" to the lung, and paralytic ileus.

Thoracic injuries may be divided into (1) subcutaneous injuries and (2) open or penetrating wounds of the chest.

SUBCUTANEOUS INJURIES

Rib fractures. Extensive pleuropulmonary damage may be produced by single or multiple rib fractures if bone fragments are depressed. At times the thoracic cage may be so badly crushed that free motion of the chest wall occurs with each inspiration and expiration. In these cases, as in those with bilateral rib fractures, shock is usually present and the dynamics of the respiration are greatly impaired. With the addition of either a pneumothorax or hemothorax the outcome may be rapidly fatal.

Opiates should be given for the relief of pain; the chest should be splinted with adhesive or elastic dressings, and intercostal nerve blocks may be performed. Oxygen may be administered by the most convenient method at hand. If bony fragments are depressed and are resulting in pleuropulmonary damage, these will require elevation.

Traumatic asphyxia. Traumatic asphyxia, produced by violent but temporary compression of the chest, may be manifested by two types of external physical findings: (1) paleness and (2) ecchymosis.

In the pale type, which is more serious, there is a pallor of the face and neck with a purplish discoloration. The pulse is fast and weak; respirations are short and irregular, the skin is cool, the patient may be unconscious. The treatment is that of shock and especially with the administration of oxygen.

The ecchymotic type results from the forcible ejection of the blood from the mediasti-

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nal veins into the valveless veins of the head and neck. Subconjunctival hemorrhages, exophthalmos, and petechiae into the skin result. Treatment is supportive with the administration of oxygen where necessary.

"Blast" injuries ("lung blast," pulmonary concussion). "Lung blast" is produced by the sudden diffuse compression of the lung through the chest and abdominal walls as a result of the detonation of a high explosive; this hemorrhagic lesion of the lung is usually unaccompanied by any significant injury to the thoracic wall.

In the severe cases the diagnosis is not difficult. The symptoms are usually those of restlessness, dyspnea, chest pain, cyanosis, and shock out of proportion to the extent of the injury. The sputum may be blood stained or frank hemoptysis may occur. The chest wall is held in a position of partial inspiration with poor respiratory excursion. Impairment of the percussion note in one area with distant breath sounds in all fields and accompanying coarse, moist râles may be demonstrated. In the less severe cases the diagnosis may be more difficult and can only be substantiated by characteristic x-ray findings. The x-ray findings resemble, in some measure, those of patchy pneumonic consolidation (13).

Zuckerman, Hooker, and Marinesco have shown experimentally that the outstanding lesion is hemorrhage into the lungs varying in degree according to the pressure to which the animals have been exposed. Osborn states that the actual lesion is mainly hemorrhage from alveolar capillaries with but little blood flowing into the bronchioles. The liberation of large quantities of mucus by ruptured goblet cells is indicative of severe damage. Subpleural "rib markings," more extensive injury in the phrenicocostal sinus, and deep and posterior lesions in the region of the hilus are indicative of a predisposition of certain parts of the lung to injury. The treatment is that of shock with liberal use of plasma. Morphine should be given with caution in the event that there has been accompanying intracranial damage. Oxygen may be administered when necessary. The sulfonamides are helpful in the prevention of pneumonia which frequently follows within 24 to 36 hours. The important factor is to appreciate the pulmonary damage and to insist on bed rest for a period of at least 24 hours.

Tears in the liver and spleen are not infrequently produced by the abdominal compression. If, in the treatment of other injuries, it becomes necessary to administer general anesthesia, intravenous sodium pentothal has been found to be least hazardous (16, 17). Williams has recommended a light induction with sodium pentothal followed by a nitrous oxide, oxygen anesthesia.

OPEN OR PENETRATING WOUNDS

Small penetrating wounds of the chest usually close spontaneously and are not of a "sucking" nature. However, if the wound remains patent, the injured individual will almost always seal the opening with his hand or with wadded clothing. The treatment in these conditions will vary with regard to the extent of the intrathoracic damage. It is usually sufficient to prepare the skin about the wound with an antiseptic, care being taken not to place irritating solutions upon the wound or to permit fluids to drain into the pleural cavity, and to take a single suture through the skin, subcutaneous tissue, and muscle down to the rib. This suture is tied only tightly enough to approximate the tissues over the pleural wound. The skin may further be closed with silk to secure more accurate approximation of the margins. Sulfanilamide may be dusted into the wound before closure if desired. To insure the cessation of leakage of air from the pleural cavity into the subcutaneous tissue, the application of a tight pressure dressing over the site of the pleural wound is imperative. Morphine is given for the relief of pain and apprehension, and Fowler's position will facilitate respiration. The administration of oxygen is rarely a necessity in uncomplicated cases.

In open sucking wounds of the chest, the lung will occasionally prolapse, and, if rib fragments are present, laceration of the lung may result. Treatment will consist in débridement of the wound under positive pressure anesthesia with the lung held to prevent its premature return into the chest. The lung is cleansed and sutured and replaced in the

chest. A layer closure of the wound is carried out. If there has been extensive damage to the lung, drainage by water seal catheter should be done.

Hemorrhage. Hemorrhage from the thoracic wall is usually not severe. Bleeding from the lung will usually be stopped when the lung is collapsed by the accumulating blood and when the rising intrapleural pressure becomes great enough to act as a tamponade. Evidence of increasing blood loss into the pleural cavity with continued shock after closure of the wound and application of pressure demands immediate operative intervention. The wound is explored under local anesthesia and any bleeding intercostal or internal mammary vessel is ligated. Hemorrhage from the pulmonary structures, when severe, is usually rapidly fatal. There are certain instances in which a prompt exploration of the chest will be necessary. Débridement and suture of large lacerated wounds of the lung, or repair of injuries to the hilar structures is of necessity attendant with high mortality. It is frequently difficult to ascertain which patients should be subjected to early radical surgery. Readily available plasma and whole blood are invaluable in the management of these cases.

Aspiration of blood from the chest is done only in those patients who show severe dyspnea or pain or in the small group who show no evidence of absorption of blood within 14 to 21 days after the accident. It is usually advisable to replace the blood with an equal volume of air to prevent further bleeding from the injured lung or vessels if the injury is of less than 3 days' duration. Since Morelli advocated the aspiration of all blood from the pleural cavity with air replacement during the World War I, this method of treatment has gained wide favor in England. This view was recently expressed by Edwards before the Royal Society of Medicine. However, in 1939 Foster sent questionnaires to leading surgeons in general hospitals throughout the United States obtaining data from 52 cities and in only 2 cities was aspiration and air injection the method of choice.

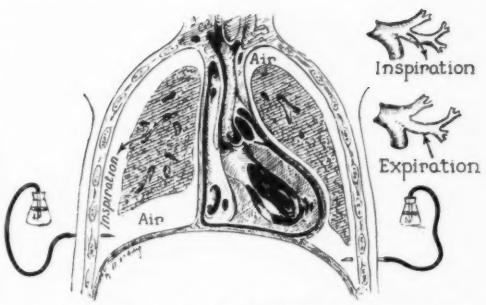

Fig. 1. Apparatus for relief of tension pneumothorax. Trapped air is released by water seal drainage.

Pneumothorax. The presence of a large volume of air within the pleural cavity is readily

Fig. 2. a, left, Extensive subcutaneous emphysema treated by layer closure of the wound with insertion of a needle for tension pneumothorax. b, Same patient 5 days following treatment.

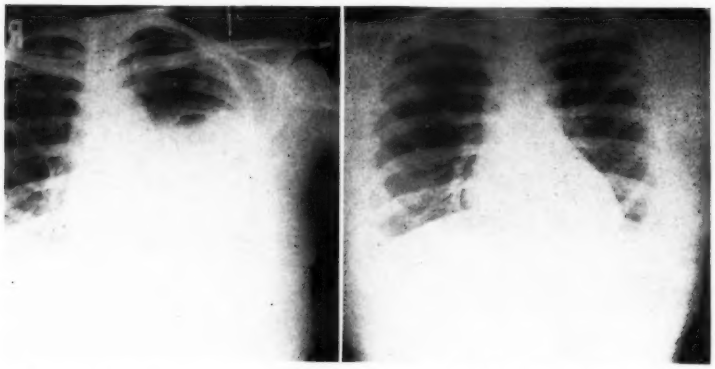

Fig. 3. a, left, Hemothorax produced by stab wound with knife. b, Roentgenogram 25 days later without aspiration.

tolerated if the pressure is not increasing. In general a conservative plan of treatment may be followed as the air is rapidly absorbed.

Not infrequently a valve-like tear of the lung or bronchioles may result, which will allow the air to enter the pleural cavity with inspiration but prevents its escape with expiration as is illustrated in Figure 1. The tension or compression pneumothorax which results will be rapidly fatal if unrecognized. The best method of treatment consists in the insertion of a large caliber, short needle into the pleural cavity; in this manner the air is permitted to escape through a connected tube which has been submerged in a flask of water under the bed.

Bilateral pneumothorax, if marked, may produce death due to the decreased vital capacity of the lungs. The air should be withdrawn by means of the method described, or simply with a needle and syringe. When the bilateral pneumothorax is slight and no distressing symptoms are present, aspiration is contraindicated.

Emphysema. With the escape of air from the normal respiratory channels in pleuropulmonary injuries, two types of emphysema may develop: (1) subcutaneous and (2) mediastinal.

Subcutaneous emphysema results from the forcing of air through a pleural rent into the subcutaneous tissue of the chest wall. Exten-

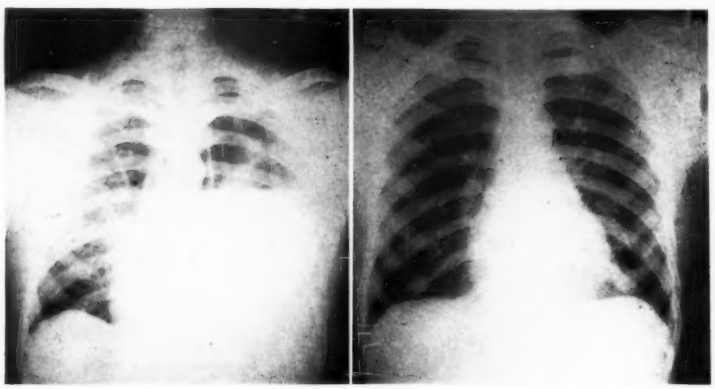

Fig. 4. a, left, Hemopneumothorax produced by stab wound with knife. b, Same case 20 days later without aspiration.

Fig. 5. a, left, Hemothorax produced by stab wound with knife. b, Roentgenogram of same patient 16 days later without aspiration.

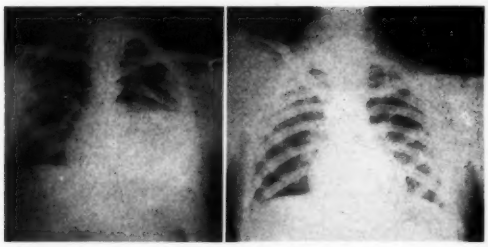

Fig. 6. a, left, Hemopneumothorax produced by stab wound with knife. b, Roentgenogram of same patient 15 days later without aspiration.

sive crepitation may also be produced by a superficial wound in a muscular area if the patient has continued to contract these muscles with the resulting mechanical dispersion of air through the part. The presence of subcutaneous crepitation about a chest laceration is not therefore necessarily diagnostic of a penetrating wound of the chest. Extensive subcutaneous emphysema is not of serious consequence except for the discomfort and mental anguish to the patient. It is usually sufficient to close the wound carefully and apply pressure more accurately over the pleural tear which, in many cases, may be far distant from the actual site of the cutaneous wound. The patient must then be carefully watched for the development of a tension pneumothorax, for the emphysema may have been a "safety valve" for the accumulating air. Similarly, if extensive subcutaneous emphysema shows no evidence of rapid disappearance after wound closure, a needle should be inserted into chest as in tension pneumothorax.

Mediastinal emphysema may result with escape of air along the peribronchial and perivascular tissue to the mediastinum. This type of emphysema may be of a serious nature if the tension is sufficiently great to interfere with the cardiorespiratory physiology. The symptoms are usually those of cardiopulmonary distress, and the diagnosis may be established by the demonstration of crepitation in the suprasternal notch, crepitation on auscultation over the sternum, or by the presence of mediastinal emphysema on x-ray examination. The treatment, if the condition is severe, consists in aspiration of air from the pleural cavity to relieve tension on the mediastinal structures, or incision in the suprasternal notch with application of suction by means of an inverted funnel sealed over the wound and connected to a source of suction.

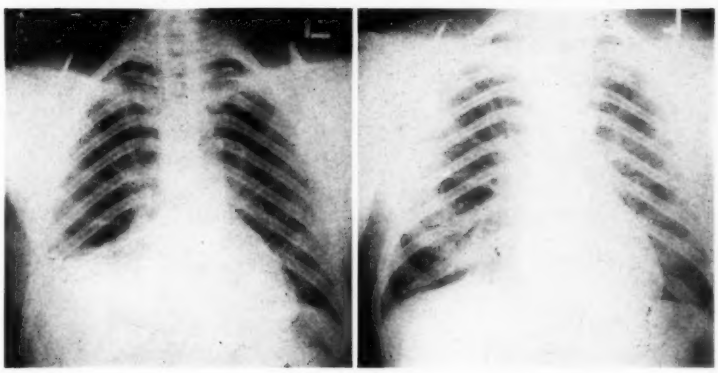

Fig. 7. a, left, Hemothorax produced by stab wound. b, Roentgenogram of same patient 16 days later without aspiration.

Fig. 8. a, left, Hemothorax and parenchymal hemorrhage produced by stab wound with knife. b, Roentgenogram of same patient 19 days later without aspiration.

Penetrating wounds of the heart. Penetrating wounds of the heart have not been included in this series, but this type of injury may be produced by stab, bullet, or freak accidents. The symptoms are those of cardiac tamponade, produced by the accumulation of blood within the pericardial sac and may vary markedly. Collapse, unconsciousness, fecal incontinence, feeble pulse, distended neck veins, profuse perspiration, and low or imperceptible blood pressure are frequent findings. The venous pressure is usually, but not invariably, elevated and may be as high as 340 millimeters of water. The most valuable single examination is the fluoroscopic visualization of the heart. The absence of visible pulsations is diagnostic of the condition. If the heart is examined and found to pulsate well, and a short while later the pulsations show more diminution in volume but are still present, the heart should be explored if the other physical findings are compatible with a diagnosis of penetrating wound of the heart. Many of these patients appear moribund and one is frequently tempted to aspirate the pericardium. However, it should be remembered that only those survive to reach the hospital and surgery who have sufficient blocking of the pericardial wound by the surrounding structures to prevent the escape of blood, thus preventing exsanguination and producing a cardiac tamponade. The tamponade in reality produces a useful function in that when the pressure becomes sufficiently high escape of blood from the heart is prevented and the heart is able to continue to function although

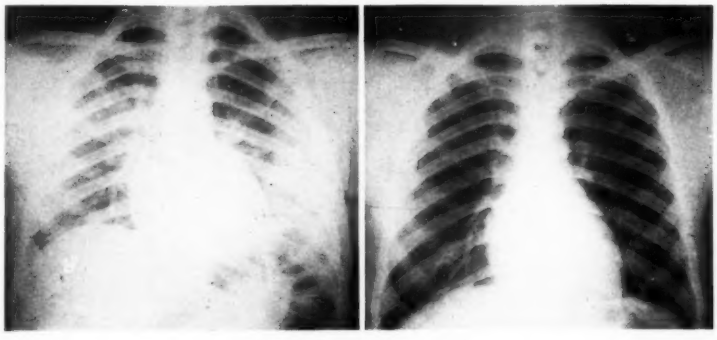

Fig. 9. a, left, Parenchymal hemorrhage due to multiple stab wounds with ice pick. b, Roentgenogram of same patient 26 days later.

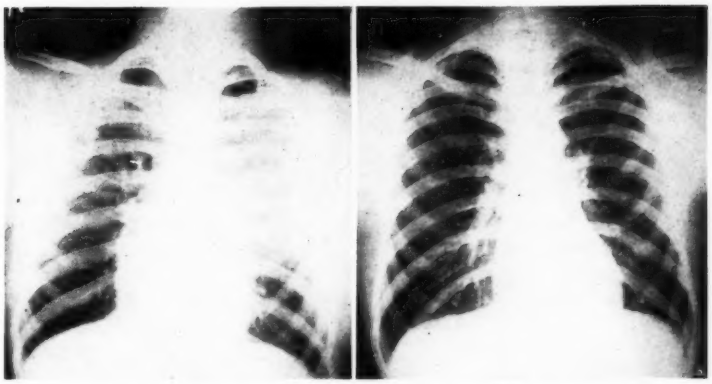

Fig. 10. a, left, Parenchymal hemorrhage due to multiple stab wounds with ice pick. b, Roentgenogram of same patient 9 days later.

the cardiac output is greatly diminished. At operation as the pericardium is rapidly opened and the pericardial contents quickly evacuated, the heart wound will frequently be seen to be temporarily sealed, only to start spurting shortly after the tamponade is removed and the intracardiac pressure again rises with unrestricted cardiac contraction.

Immediate surgery offers the patient the only chance for survival. The quickest and most satisfactory approach is through a transverse incision, with removal of one or more cartilages and a portion of the sternum. The intercostal and internal mammary vessels are ligated. The pleura is dissected laterally by blunt gauze dissection. The pericardium is opened and the contents evacuated. Silk sutures are placed in the heart wound which may be covered by a finger until the suture can be taken. The pericardium and wound are then closed in layers with black silk.

REVIEW OF CASES

Wounds of the chest occurring in civilian practice differ from those incurred in warfare in that they are less extensive and are not associated with the same degree of contamination from foreign bodies, dirt, rib fragments, and clothing carried into the chest by the missiles.

During the past 8 years 1,132 penetrating wounds of the chest have been admitted to the Emory Division of Grady Hospital. The mortality rate in this group was 6.36 per cent. Of this number 117 were gunshot wounds while the remaining were produced by knives or ice picks. The most frequent injury was one produced by a so called "switch blade" knife, this weapon having a narrow blade approximately 4 inches long. The ice pick usually produces a hemopneumothorax, but not infrequently the picture is one of parenchymal hemorrhage. During the past 2 years 418 cases have been treated with a mortality of 3.3 per cent. In the former group the incidence of empyema was 1.76 per cent.

One hundred consecutive cases of penetrating wounds of the chest have been carefully followed by frequent roentgenograms and physical examinations over a period of 1 year. In this group were 86 knife wounds, 9 from ice picks, and 5 gunshot wounds. Hemoptysis was noted in 14 per cent, subcutaneous crepitation in 82 per cent, and sucking wounds in 16 per cent. Patients with stab wounds of the heart or with associated intra-abdominal injury have been omitted from this series. During this period 2 fatalities occurred, with both patients dying within a short time after admission. It was thought that death was due to hemorrhage from large pulmonary vessels. Autopsies were not obtained in either case.

The venous pressure was found to vary from 110–300 millimeters of water, averaging 174 millimeters of water. The pressure was meas-

ured with the patient lying flat with manometer on a level with the skin of the back. In contrast to the common finding of incontinence of feces and urine in patients with stab wounds of the heart, only 2 of this group were thus affected.

X-ray examination revealed a pure hemothorax in 38 per cent, a pneumothorax in 18 per cent and a combined hemopneumothorax in 35 per cent. Parenchymal hemorrhage was present in 9 cases, 7 of these cases being in multiple ice pick stab wounds of the chest.

RESULTS

Eighty-nine per cent of the patients showed no x-ray evidence of pulmonary lesions within 5 to 29 days. There was no residual pleural thickening. The average time required for absorption of the blood and air was 17 days in this group.

Nine patients showed evidence of delayed absorption of blood and 8 of these cases were aspirated with replacement of the fluid removed with air. The process then cleared completely within from 35 days to 5 months. The 5 month period for resolution of pleural thickening was required in a patient who developed numerous encapsulated pockets of fluid. In this group 2 patients developed empyema which was treated by thoracotomy and rib resection.

SUMMARY AND CONCLUSIONS

1. The principal considerations in the treatment of all chest injuries are: (a) the restoration of normal cardiorespiratory physiology, (b) the treatment of shock, and (c) the treatment of any complications or sequelae which may arise.

2. A total of 1,132 cases of penetrating wounds of the chest is presented, with a mortality of 6.36 per cent and with a 1.76 per cent incidence of empyema.

3. The treatment of chest injuries is, in general, conservative, and nonoperative.

4. Aspiration of blood with air replacement is indicated in case of dyspnea, severe pain, or delayed absorption of blood.

5. In a group of 100 consecutive patients 89 per cent showed no x-ray evidence of pulmonary lesions after 29 days (average 17 days); 98 per cent had no evidence of pleural thickening at the end of 5 months.

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CYSTOSARCOMA PHYLLOIDES

With a Consideration of Its More Malignant Variant

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THIS paper reports 3 cases of cystosarcoma phylloides of the female breast, one of which has metastasized to the axillary lymph nodes. In searching the literature, we have failed to find any case similarly illustrated with photomicrographs.

Cystosarcoma phylloides is the most common of scores of names used for this tumor. We therefore retain it with the following definition: It is a tumor arising from the connective tissue of a pre-existing mammary adenofibroma. The clinical history usually obtained is that the patient in her fourth or fifth decade has been aware of a quiescent, small, hard breast nodule for many years with later growth to a huge size without associated constitutional symptoms. On examination, the breast is found tremendously enlarged and characteristically ovoid in shape. The overlying skin and nipple are not invaded, although local extension may have taken place to the adjacent structures. Regional lymphadenopathy is not evident unless infection is superimposed. Grossly, the tumor is found to contain frond-like pleats resembling a head of cauliflower, from which appearance it takes its name. Microscopically, the unique finding is the increase in the fibrous elements. The associated metaplastic changes, areas of ectopic cartilage or bone, and the acinar proliferation which sometimes occur are not of definitive value. "Atypical carcinoma," lymphosarcoma, and diffuse fibrosarcoma of the breast must be rigidly excluded from this group. These patients usually do well when treated by wide local excision, and the prognosis in general is good.

Although Sir Ashley Cooper and Brodie mentioned this tumor, Johannes Mueller, in 1838, gave a classical description of several cases, calling them cystosarcoma phylloides and clearly separating this from the general group of breast lesions. Velpeau and others have reported patients with enormous mammae weighing up to 40 pounds. Axillary lymph node involvement is but rarely noted, and then mention is made of complicating factors which raise the possibility that the enlargement is due either to extraneous causes or is of an unproved nature. For instance, in the 16 cases reviewed by Rose, none had lymph node involvement. Boldrey listed 4 cases of fibrosarcoma, of which one had enlarged lymph nodes, but it is stated that they were "due to tuberculous infection." Williams in 24 cases had 2 in which lymph gland dissemination had occurred. Both of these were of the "round cell variety of the disease" and possibly represented lymphosarcoma. In other instances, clinical mention was made of palpable (i.e. enlarged) lymph nodes, but microscopic examination or photographic evidence or both was not given. Hill and Stout suggest that "metastasis to the axilla probably never occurred." Growth during pregnancy is infrequent, but increase in size during the menopause has been noted occasionally. As the age group of these patients extends through the years of the climacteric, the association of growth with the menopause may be but coincidental. Many writers emphasize the generally benign course of cystosarcoma phylloides (7), and there are examples of 5 year arrests following local excision: yet not all cases of cystosarcoma phylloides run this benign course. An occasional instance of pulmonary (4), osseous (11) or extensive local spread with eventual fatality is mentioned. One remarkable case of a persistent surgeon and submissive patient was recorded by Hoffman wherein 12 recurrences occurred and 12 operations were

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Fig. 1. Case 1. Note ulceration and frond-like projections.

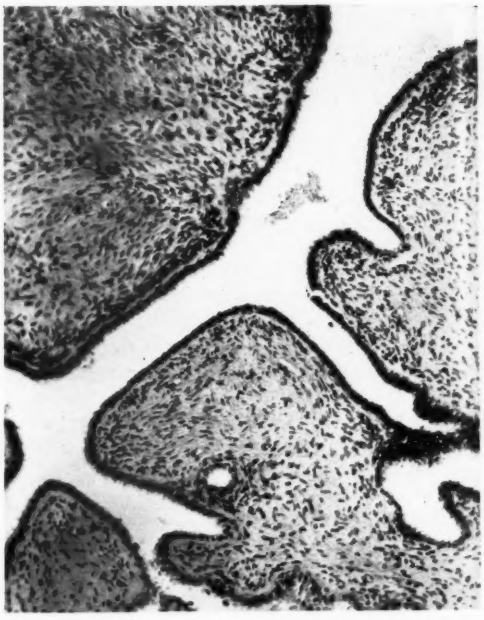

Fig. 2. Case 1. Photomicrograph demonstrating intracanalicular appearance of the tumor with marked proliferation of the connective tissue. Hematoxylin and eosin. × 255.

performed. A 4 year period of freedom from disease ensued, only to be followed by eventual death from metastases. In discussing "a malignant variant of cystosarcoma phylloides," White reported a case with "autopsy showing extensive growth on the chest at the site of removal of the left breast, metastases in the right breast, in the anterior mediastinum and in the lungs." Excellent reviews of the subject are available (5, 7).

The following is a brief summary of our 3 cases. Two of them represent the benign and one the malignant variant of this disease.

Case 1. A. O., EFSCH No. 4252, a 57 year old white American housewife, had a 3 to 4 centimeter movable nodule in the left breast for 3 years with slow growth until 5 months prior to admission, when it enlarged to a mass 21 by 20 centimeters in size. Examination here (June 24, 1942) showed a large mass replacing the left breast (Fig. 1). The tumor was ulcerated through the skin in one area and on the same side 3 axillary lymph nodes measuring 2 centimeters in diameter were palpable. It was our opinion that the lymphadenopathy was associated not with metastatic disease in the nodes, but with an inflammatory response to the superimposed infection. Complete skeletal series was negative for evidence of pulmonary or osseous metastases. A simple mammectomy was done on June 30. The subsequent course (9 months) has been uneventful. The gross specimen weighed 1,940 grams and contained a large tumor mass which had fungated through the skin. It was made up of various sized nodules with clefts and lacunae between them. Microscopically, early connective tissue proliferation of the intracanalicular type was seen (Fig. 2).

This case presents a typical picture of cystosarcoma phylloides. The patient was in her sixth decade and the breast fibroma was known to have been present in the quiescent stage for 2½ years before rapid growth began. No cause for the onset of proliferation can be given. The menopause had occurred some 10 years before. The aforementioned lymphadenopathy disappeared with the removal of the inflammatory lesion, and the prognosis from wide local excision alone should be excellent.

Fig. 3. Case 2. The breast is drop-shaped, and the nipple has been flattened.

Fig. 4. Case 3. Tumor recurrence growing in the region of the previous operation.

Case 2. C. W., EFSCH No. 3958, a 75 year old white American housewife, had a 3 centimeter nodule present in the upper and outer quadrant of the right breast without increase in size for 10 years. Six months prior to admission (April 6, 1942) rapid growth began. Examination revealed a 15 by 15 centimeter, drop-shaped mass in the breast without skin or muscle fixation (Fig. 3). No lymphadenopathy was present. Skeletal series was negative for evidence of pulmonary or osseous metastases. On April 8, a simple mammectomy was done. The gross specimen weighed 1,130 grams and was similar in appearance to that of the first case except that skin ulceration had not occurred. Microscopically, proliferation of connective tissue with an occasional area of myxoma-like stroma was present. Evidence of the tumor's origin from an adenofibroma could again be demonstrated.

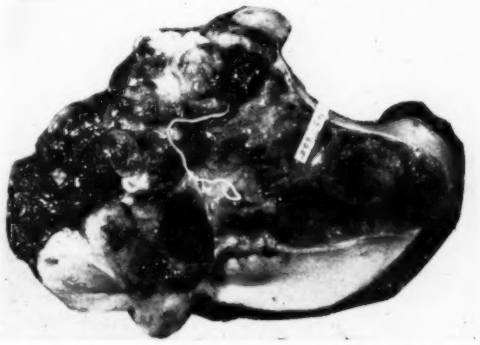

Fig. 5b.

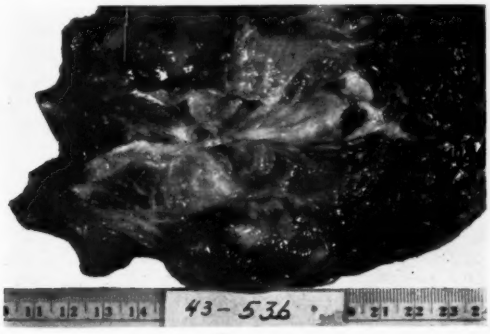

Fig. 5. Case 3. Observe tumor just beneath the skin and its gelatinous and hemorrhagic appearance. a, above, First recurrence; b, third recurrence; c, fifth recurrence.

Fig. 5c.

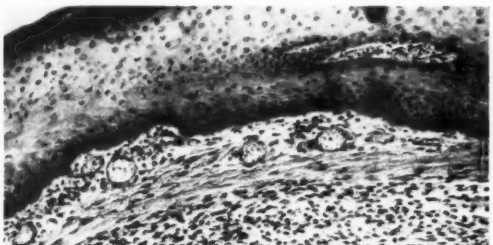

Fig. 6. Case 3. Note tumor growing just beneath the skin. Cellularity is increased, and there are areas of myxomatous change in the stroma. Hematoxylin and eosin. × 220.

This patient also represents the usual picture of cystosarcoma phylloides, with the exception of her advanced age. In patients aged 75, most massive breast tumors are carcinomas and cystosarcoma phylloides is seldom considered in the differential diagnosis. Her postoperative course (11 months) has been uneventful, and no evidence of local or distant recurrence was found at her last clinic visit.

Case 3. C. G., EFSCH No. 4034, a 51 year old white American housewife, had a 1 centimeter movable nodule just lateral to the nipple of the left breast for 12 years. Three years prior to admission, it began to grow, until 10 months before being seen here, a part of the tumor weighing 1,750 grams was removed by her family physician. Eight months later, a recurrence was evident in the scar. She was referred to us, but admission was not sought for 2 months. Examination then, April 26, 1942, showed a nodular, tender mass 5 centimeters in diameter protruding from the excision scar in the left breast (Fig. 4). The ipsilateral axillary lymph nodes were not palpable. Complete skeletal series was negative for evidence of pulmonary or osseous metastases. A left radical mastectomy with split graft was done on April 29. Her immediate postoperative course was uneventful, but a second recurrence was noted 6 months later. At removal, on October 16, tumor was found on the chest wall overlying the 7th rib at the midclavicular line. A third recurrence was noted in 3 months, and at operation on January 23, 1943, a tumor was found penetrating the chest wall anteriorly and a second mass burrowing between the thoracic wall and the scapula. These were removed. X-ray later showed "possible pleural metastases" subjacent to the rib, from which the recurrence had been removed. Grossly, the specimen removed before admission showed nodular, soft tumor tissue beneath an intact skin. It was made up of numerous nodules and intricate clefts. On section, it was grayish-white with multiple areas of hemorrhage and some gelatinous zones. Tumor extended to the limits of excision. The subsequent specimens were similar in appearance except that areas of hemorrhage and gelatinous change were more prominent, and that from the radical mastectomy showed invasion of muscle and enlargement of three lymph nodes (Figs. 5, 6, 7). Microscopic sections showed interlacing bands of connective tissue. The nuclei were spindle-shaped and fairly uniform in size. There were, however, fairly numerous mitotic figures present with occasional areas showing marked variation in cell size. These areas of fibrous anaplasia were patchy in distribution, alternating with fields in which tumor was of the usual innocent appearance. The myxomatous zones showed fairly marked cellularity and resembled the embryonal type of connective tissue. Phosphotungstic acid stains demonstrated numerous fibroglia fibrils. Muscle invasion was evident, and 3 of 14 lymph nodes examined were completely replaced by tumor tissue of the same characteristics as that described in the primary breast lesion.*

This case, although as assuredly one of cystosarcoma as the others, has run a different and more malignant course. The original

*This finding of lymph node metastasis, although unexpected, is not incredible. It parallels the occurrence of this mode of spread occasionally seen in fibrosarcoma arising in other locations (11).

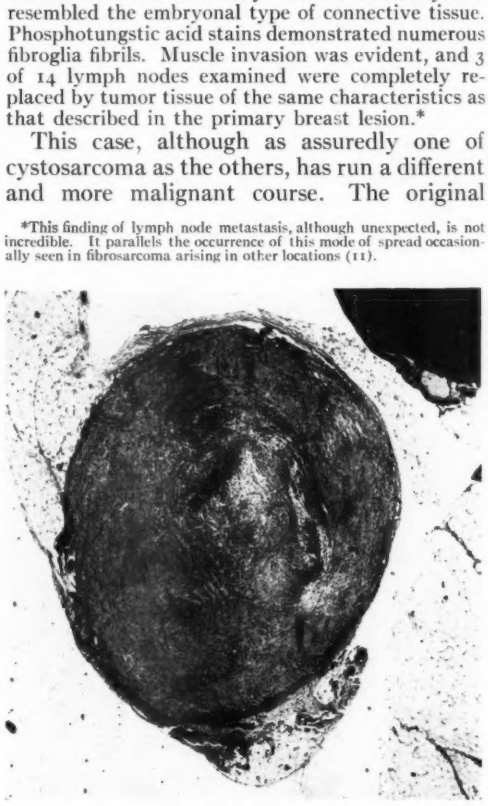

Fig. 7. Case 3. This axillary lymph node is completely replaced by tumor. Hematoxylin and eosin. × 64.

breast nodule was present for 9 years without increase in size and for 3 years more with very slow growth. A first removal was followed by local recurrence in 10 months, a second and more radical removal by recurrence in 6 months, and a third and fourth by wider and still more extensive recurrence in 3 and 2 months, respectively. There was no association of pregnancy or the menopause with this increased rate of growth. Clinically, it and the other cases previously cited in the literature (12, 13) which also ran a rapidly malignant course, differ from the usual case of cystosarcoma phylloides by certain specific particulars, viz.: the history is notable because of either rapid growth or swift recurrence. Examination of the patient is noncontributory but fixation of the mass to underlying tissue, if present, would demonstrate muscle invasion. The presence or absence of palpable axillary lymph nodes is not of significance either as to their involvement in, or freedom from, metastatic disease. Most important, the fresh operating room specimen is softer and shows lobules which are less clearly outlined than those of the classical cystosarcoma phylloides. The surface is mucoid, without the dry and definite appearance of the more benign lesion. Areas of fleshy tint with gelatinous zones and dark blue blotches of glairy hemorrhage suggest its more dangerous nature. Muscle involvement, if demonstrable, makes this unequivocal. A frozen section obtained at operation, coupled with this gross appearance, should help lead to the correct diagnostic conclusion. In order to avoid spillage of tumor cells, extreme care must be used in obtaining the material for frozen section.

SUMMARY

Cystosarcoma phylloides is an interesting and not too uncommon sarcoma of the breast, about 125 cases having been reported. Treatment by wide local excision is usually satisfactory. The use of x-ray therapy is probably not indicated. There occurs, however, marked variation in the lethal potentialities of these growths. In our first and second cases the tumor was relatively benign, and in lesions of this, the usual type of cystosarcoma phylloides, a simple mammectomy suffices. Our third example stands at the other end of the scale and in its behavior resembles fibrosarcomas arising in other sites. In variants of such a degree of malignant tumor, the principal reliance of the surgeon for cure must be placed in an extremely wide local excision of the breast and surrounding structures. Muscle involvement, when present, makes removal of the pectoralis major and minor obligatory, and we now feel that, once these muscles have been removed, an axillary dissection should be done, intelligent exceptions to this being made when justified in a particular case.

From a presentation of 3 patients with cystosarcoma phylloides seen personally and from the experience of others as seen in the literature, it is suggested that cystosarcoma of the breast is, like all neoplasms, one whose potentialities vary from that of a very benign to that of a very malignant lesion. Our third case with invasion of muscle, metastases to axillary lymph nodes, and frequent recurrences represents the most malignant type. This variant requires a classical radical mastectomy with axillary dissection for cure.

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RADIODERMATITIS OF THE HEAD AND NECK WITH A DISCUSSION OF ITS SURGICAL TREATMENT

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SERIOUS results may follow either inadequately controlled radium and roentgen therapy or the injudicious use of roentgen rays for diagnostic purposes. Radiodermatitis often has resulted from procedures carried out by inexperienced practitioners and by lay operators, but it may occur even in the hands of competent radiologists and at times with comparatively small doses. The hazards incident to the use of radium and roentgen rays have been known to the medical profession for many years and, as a result of prophylactic measures now generally carried out, the incidence of such lesions is decreasing.

The condition often produces severe disability and marked deformity but its tendency to undergo malignant change is of even greater seriousness. While conservative measures are indicated for the treatment of the acute stages of the process and for mild chronic lesions, actual removal of the affected tissue affords the only means of relief when secondary irradiation changes are pronounced.

Chronic radiodermatitis is encountered fairly frequently. It occurs more often following roentgen therapy than after radium treatment, and the former is usually of greater seriousness because of the more extensive area involved. The total dose given and the various factors concerned with its administration are chiefly responsible for these serious cutaneous changes but the tendency to induce such a reaction often is increased by rays from other sources, such as sunlight and ultraviolet and infra-red irradiation, and also by chronic irritation of other types. Moreover, it has been observed that the skin of certain persons is unduly sensitive to irradiation, either because of lack of normal pigment or because of an idiosyncrasy. Excessive reaction is observed particularly among those who have a fair or ruddy complexion, red hair or a thin, dry skin. A single roentgen diagnostic procedure or one application of radiotherapy has produced at times extensive burns and necrosis among such patients. Men and women appear to be about equally affected. The condition occurs more frequently about the head and neck than in other portions of the body, probably because of the greater number of irradiation exposures made to these surfaces, rather than because of any possible difference in the susceptibility of the skin of these parts.

In a number of cases the most severe manifestations of radiodermatitis have followed irradiation used for comparatively minor conditions such as acne, eczema, psoriasis, pruritus ani, hypertrichosis, warts, and other dermatological lesions. Many of the patients who had marked secondary radium and roentgen ray changes about the head and neck coming under our observation had received treatment for tuberculous cervical adenitis, actinomycosis, goiter, and various skin conditions. In a few instances treatment for deep-seated neoplasms had been responsible for the changes. In these cases as in those resulting from treatment of malignant lesions of the skin, the physician at least has the satisfaction of knowing that the condition induced usually is less serious than that for which treatment was given. This is decidedly in contrast to the sense of consternation and dismay caused by realization that treatment of a benign process has brought about pathological changes that not only are painful and disabling but bear the possibility of cancerous degeneration.

Some of the most extensive lesions that we have encountered resulted from the use of roentgen therapy by operators of beauty shops for depilatory purposes. In some instances the condition was induced by repeated applications of radium and roentgen rays to angiomas, especially of the port-wine stain type, a lesion that is notoriously radioresistant and that physicians generally agree should not be subjected to intensive irradiation.

In a considerable proportion of the reported series of cases of radiodermatitis the patient is a physician, a dentist, or a radium or roentgen ray technician who has been exposed to the rays while carrying on his professional duties. In a group of 259 cases of this condition reported by Saunders and Montgomery, physicians and dentists comprised 10 per cent of the patients, and in Codman's series they made up 30 per cent. Involvement of the hands is present among most of these patients.

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Since the lesions under consideration in our paper are limited to the head and neck, no professional workers are included in the group except for a few who had received irradiation for lesions in this region. In a group of 55 physicians who had radiodermatitis and whose cases were reported by Leddy none had involvement of the face.

Insufficient protection and lack of appreciation of the serious possibilities of improperly controlled irradiation have been largely responsible for the majority of these injuries. It seems likely that better equipment, refinements of technique, and increased experience will greatly lessen the incidence of the condition in the future. However, in view of the present wide use of roentgen therapy in fractional doses and the severe acute reaction induced in most of these cases, one cannot but wonder whether serious secondary changes will not develop later in a large proportion of cases. Regardless of this possibility, the results obtained well justify this type of treatment, for without it most of these patients face a hopeless outlook.

Radiodermatitis may occur either as an acute process reaching its height within a few weeks following exposure to the rays or as a chronic condition becoming manifest only after the lapse of months or years. Depending on the dose, the screening, and the sensitivity of the patient's skin, the immediate or acute reaction may be so mild as to be scarcely evident clinically. On the other hand, the condition may present vesiculation, necrosis, and sloughing of varying extent accompanied by severe secondary infection and intense pain. The acute form is comparable to the three stages of burns except that the process progresses much more slowly. A dusky blue erythema is noted at the end of 2 weeks and either exuding or dry dermatitis after 3 weeks. A permanent brown discoloration due to increase of melanin and temporary or permanent loss of hair may follow this. At times when the acute reaction has been severe, complete loss of pigment results later.

The necrosis, sloughing, and secondary infection of this stage often produce protracted disability, for healing occurs only after many weeks or months. The most destructive effect of the irradiation occurs in a central area and gradually decreases toward the periphery of the exposed surface. The inflammatory and circulatory changes resulting from this gradation taper off so imperceptibly that it is impossible to recognize a definite line of demarcation between the devitalized and the healthy tissue. Months after the delayed healing the central portion of the area may break down again and the prolonged, painful

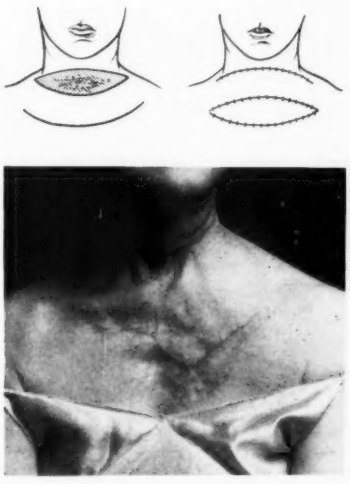

Fig. 1. a, above, Plan of removal of actinodermatitis at base of neck anteriorly and immediate repair by means of double pedicle flap, a skin graft being applied to the donor site; b, result 4 months following operation.

sloughing and ulceration recur. We have seen this process repeated several times during the course of a number of years following treatment of an extensive carcinoma on the base of the tongue. At the time of the acute flare-ups of the condition it was impossible to determine whether the process was inflammatory or a recurrence of the neoplasm. Unless the acute reaction has been very mild some permanent changes of the skin remain following its subsidence. Often these are scarcely discernible immediately after clearing of the acute process but become increasingly manifest during the course of a few months or at times only after the lapse of several years. Ulcers appearing during the reaction immediately following irradiation may persist as such but, more commonly, lesions of this type encountered in chronic radiodermatitis occur later as the result of secondary changes.

Chronic radiodermatitis is usually preceded by the acute form, a latent period of from 1 to 10 years generally intervening. It may result from repeated small exposures. In none of Leddy's series of 55 cases of such lesions occurring among physicians did the condition develop without there being obvious cutaneous changes present during the interim. Marked circulatory changes, dryness, fissuring, telangiectasia and atrophy of the cutaneous surface with disappearance of the sweat and sebaceous glands and hair follicles take place, giving the skin a smooth, dry, glistening appearance. Keratoses, sclerosis, and induration

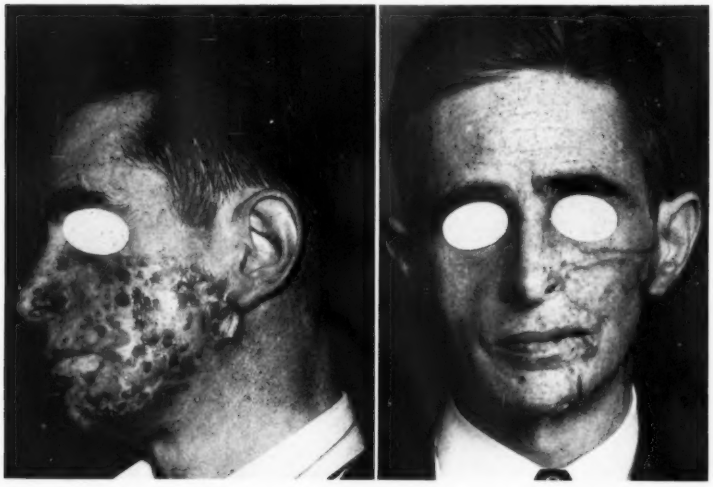

Fig. 2. a, left, Actinodermatitis resulting from treatment of impetigo 2½ years previously; b, result following excision and repair with thin shaved grafts. It had been planned to recover the areas later with full thickness grafts but the appearance improved to such an extent that the patient decided to have nothing further done.

develop later, and the skin becomes thick, leathery, and immobile. Necrosis, sloughing, and ulceration develop as a result of the atrophy of the skin and obliteration of its vascular supply. The ulcers vary from superficial lesions to deep craters that have thick, indurated edges and a necrotic base and may be fixed to the underlying structures. Fairly frequently, bone, cartilage, tendon, and muscle become exposed and perforation into the mouth, nose, larynx, and trachea at times occurs. The ulcers are extremely indolent and show little or no tendency to heal. Crusting due to the exudate from the ulcer is usually present and secondary infection with attendant pocketing of purulent material takes place. Intensive pruritus and severe, constant pain are complained of and are difficult to control. A complicating factor associated with the pruritus is the trauma produced by scratching.

Malignant changes often develop in the keratoses and persistent ulcers. The resulting epitheliomas usually are of squamous cell type. Their incidence in cases of radiodermatitis varies with the severity of the primary irradiation injury and the stage in which the cases are studied. Malignant lesions developed in 10 per cent of the group of 259 such cases reported by Saunders and Montgomery. However, when only patients who had the more severe irradiation changes were considered, the proportion increased to 19 per cent. A long latent period almost invariably intervenes between the time of the initial exposure and the appearance of epitheliomatous change. This may be of only a few months' duration but more frequently it is at least several years in length and often it is more than a decade.

The activity of malignant lesions developing on this basis may range from 1 to 4, according to Broders' classification. The majority of them are of moderate activity or of low grade, but fulminating malignant lesions may be present. In general because of the surrounding sclerosis, even the highly malignant neoplasms among these are less likely to metastasize than other neoplasms of similar activity. Thus treatment carried out reasonably promptly after appearance of the malignant process should offer a satisfactory prognosis.

Because of the sclerosis and ulceration, contractures often are present but, because of the absence of keloids, contractures occur less commonly in cases of radiodermatitis than after the usual burn due to heat or caustic. The degree of deformity depends on the situation, extent, and severity of the involvement. It may be marked about the eyelids, lips, and nostrils, especially if extensive ulceration is present or malignant change has supervened, and may constitute one of the most serious features of the condition.

PATHOLOGY

The histopathological characteristics of radiodermatitis have been shown to be the same

Fig. 3a.

Fig. 3b.

Fig. 3c.

following roentgen and radium applications. Studies of these lesions in man and in experimental animals were made by Wolbach, who noted (1) complete loss of the appendages of the skin as evidenced by the destruction of hair follicles and of sebaceous and sweat glands; (2) the replacement of normal collagen by a peculiar dense hyaline collagen rich in apparently new formed elastic and quite cellular tissue; (3) obliteration of the small vessels in the corium of the skin and subcutaneous tissues, the larger vessels showing varying degrees of thickening of the adventitia and media, and proliferation of the intima; (4) necrosis and rarefaction in the corium just under the epidermis, which usually were associated with thrombosed regions of telangiectasia; (5) reparative proliferation with hypertrophy of the epidermis.

Fig. 3d.

Fig. 3. a and b, Radiodermatitis resulting from treatment of capillary angioma 7 years previously; c and d, result following excision and full thickness skin graft.

TREATMENT

During the acute stage of actinodermatitis the results of operative procedures are likely to be disappointing, since it is difficult to determine the extent of the process. Only the tissues most seriously affected tend to slough, but unless these are removed completely, further necrosis will occur. In general, provided that damage to the tissue has not been unusually severe, the acute reaction is self-limiting and runs its course in a few weeks or months regardless of therapeutic measures instituted. During this period considerable palliation can be afforded by applications of a drying lotion or soothing ointments and by measures directed at combating the infection and acute inflammatory reaction, such as painting the sloughing area with a solution of acriflavine and gentian violet, dusting it freely with sulfathiazole powder and the use of warm, moist compresses. Radical measures are contraindicated at this time, for in the presence of the exudation, infection, and sloughing, they are likely to aggravate the condition and prolong the period of disability and pain.

The treatment indicated in cases of chronic radiodermatitis depends on the severity and extent of the changes, on whether epithelioma is present and on the age and general condition of the patient. Various types of dermatological treatment may keep the patient who has this condition reasonably comfortable provided that secondary changes are not advanced. However,

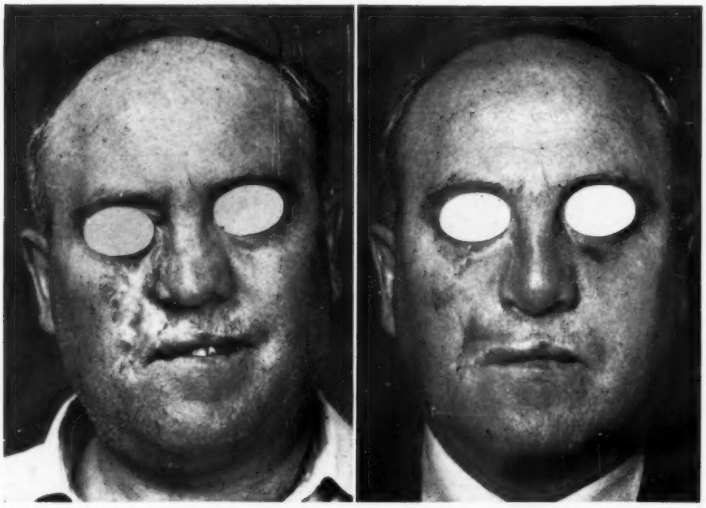

Fig. 4. a, left, Radium dermatitis resulting from treatment of angioma 15 years previously; b, result following excision and full thickness skin graft.

when sclerosis, atrophy, and hyperkeratosis are pronounced and ulceration is present, only surgical treatment is likely to afford relief. If malignant change has developed, surgical removal is imperative.

The surgical treatment of chronic radiodermatitis consists of two parts: (1) removal of the diseased tissues and (2) repair of the resultant defect. In general these two stages are combined as a single operative procedure and it usually is decidedly advantageous to do so. However, when there is considerable infection or necrosis present and when malignant change has taken place and is advanced, it is at times advisable to remove the involved tissue widely, leave the wound open, and repair the defect at a later stage. This is especially true in cases of extensive or high grade malignant lesions and particularly if the tumor is fixed to the underlying bone or is so situated that only limited removal of tissue is possible. Delaying repair for some months in these cases allows the wound to heal over and the tissue to scar down. This may render it more difficult to secure a satisfactory cosmetic result but the open wound permits of closer scrutiny for possible recurrence of the neoplasm, and the prognosis is greatly improved.

Fig. 5. a, left, Extensive epithelioma (basal cell and squamous cell, grade 1) developing in radiodermatitis following treatment of tuberculous adenitis in adolescence; b, result following diathermic excision and immediate application of dermatome graft of moderate thickness.

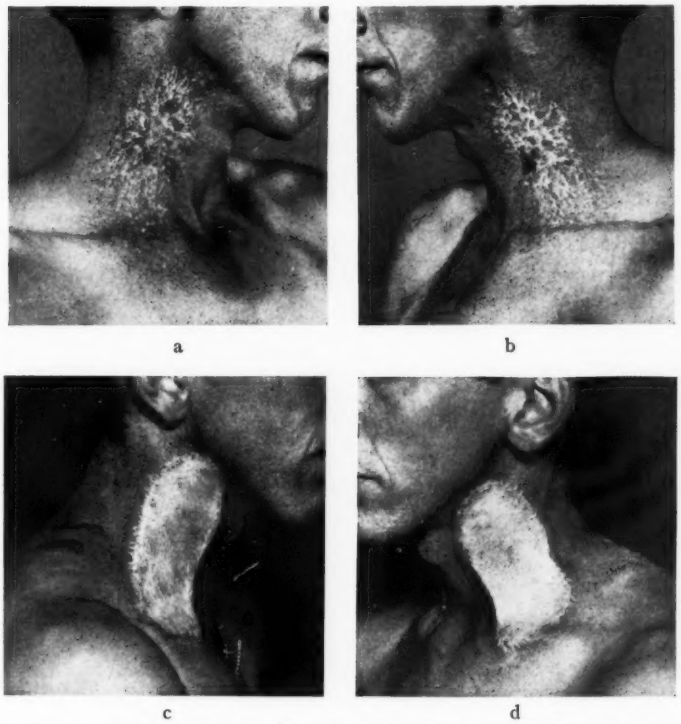

Fig. 6. a and b, Radium dermatitis of both sides of neck resulting from treatment of extensive squamous cell epithelioma (grade 4) of nasopharynx with bilateral cervical metastasis 12 years previously; c and d, result following excision and full thickness skin grafts.

At times a lesion that has appeared clinically to be malignant will be found on microscopic examination following excision to be only a benign hyperplastic process but as this condition is potentially malignant, the removal of the tissue for prophylactic purposes is advisable. Fairly frequently, too, fixation in these cases is found at operation to be due to the extensive sclerosis and infiltration rather than to the presence of a neoplasm that has become attached to the underlying bony structures or is invading them. Such operative findings may permit of immediate repair when this had not been anticipated before operation. Fresh frozen sections, which afford the opportunity of immediate microscopic study, are decidedly advantageous in these cases since the report of the pathologist can be obtained within a very few minutes and while the operation is still in progress. The surgeon then is able to deal with the condition much more rationally than when he must rely entirely on the gross appearance of the lesion. Accurate information concerning the histopathological characteristics and the limits of any malignant change that may be present is of the utmost value in determining the width of removal advisable and whether immediate plastic repair is justifiable.

Excision of a region of radiodermatitis serves several purposes. Primarily it removes the pathological process, and the removal in most cases affords immediate relief from the distressing symptoms whether the wound is closed immediately or is left open. It relaxes any contracture that may be present, permits histological study for possible malignant change and prepares a graft bed with an improved blood supply. The subsequent repair properly done furnishes an approximately normal integument, thereby improving the patient's appearance and restoring function.

As a rule little difficulty is experienced in determining the essential width of removal of such

a b c

Fig. 7. a, Extensive epithelioma developing in radiodermatitis resulting from treatment for capillary hemangioma of port-wine stain type; b, excision and immediate transfer of previously prepared flat pedicle flap from arm. The donor site on the arm was covered with a full thickness skin graft; c, result following foregoing procedure. Complete removal of lower eyelid was necessary. Mucous membrane graft from inside cheek was used to line eyelid.

lesions. Excision must extend well beyond the region of marked tissue change regardless of the structures involved; otherwise progression of the condition is likely to necessitate further surgical removal later. At times during the procedure large blood vessels, nerves, tendons, and other important structures are uncovered and sacrifice of some of these may be necessary. Bony parts fairly frequently are exposed by the ulceration or during removal of the involved soft tissues. In this connection it is well to bear in mind that necrotic bone—especially about the cranium—resulting from irradiation is extremely slow to sequestrate. Often this process will require a year or more, whereas a sequestrum resulting from the use of the actual cautery or electrocoagulation separates within a few months depending on its thickness. Rather than delay closure of the wound until after dead bone has been extruded spontaneously it usually is preferable to remove the bone surgically. As the limits of necrosis frequently are not discernible grossly, removal should be made well into freely bleeding osseous tissue. Drilling multiple small perforations through the devitalized bone will permit granulations to develop and at times these will coalesce over the bony surface and permit of covering it with a graft, but actual removal of the involved bone is preferable.

Excision of the soft tissues need not necessarily extend entirely beyond the region of sclerosis and telangiectasia, for while it may be desirable to get rid of all of the involved tissue, its complete eradication might produce a defect of such extent that repair would be extremely difficult. Then too, some lessening of the degree of postradiation change in this peripheral zone usually occurs after removal of the more severely damaged tissues, probably largely the result of subsidence of the inflammatory reaction. Removal may be carried out either sharply or with the electrocoagulation scalpel. The latter is advantageous when secondary closure of the wound is planned, since the vascular oozing can be controlled more readily, but it may be employed even though immediate skin grafting is to be done. A graft will usually take readily on a surface thus prepared unless undue searing has been necessary. The line of demarcation between the involved and normal tissues as a rule is readily recognized and separation is easily effected. Severe bleeding usually is not encountered provided there is not excessive acute inflammatory reaction.

The method of repairing the defect following removal of a lesion of this type depends on several factors. Chief among these are the situation and extent of the involvement, the age and sex of the patient, and the presence or absence of epithelioma. Regions of actinodermatitis of limited expanse can be excised at times and the wound sutured primarily after the edges have been undercut widely. Care should be exercised to extend the incisions approximately parallel to the normal cleavage lines of the skin, unless this will

Fig. 8a.

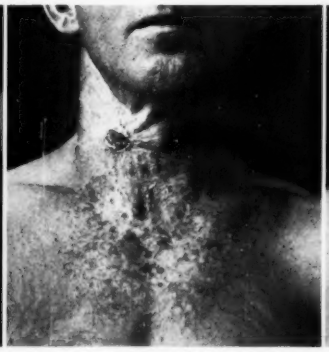

Fig. 8b.

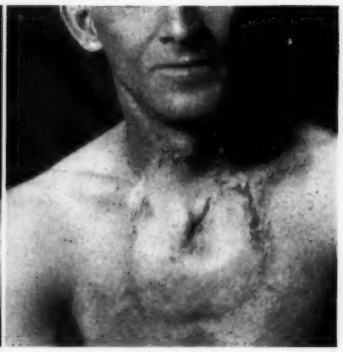

Fig. 8d.

entail sacrifice of an undue amount of normal tissue, and also to support the subcutaneous tissues well with fine silk sutures and to approximate the margins of the skin accurately so as to render the operative scar as inconspicuous as possible.

Benign lesions of considerable spread, if not infected, can be removed advantageously at times by means of multiple partial excisions. According to this procedure, which frequently is of value also in dealing with other types of superficial nonmalignant processes, a portion of the region of such width that the margins of the defect following its removal can just be approximated is excised and the wound is sutured. Several months are then allowed to elapse in order to permit the adjacent skin to relax. Further excision is then carried out and the process is repeated subsequently until the entire lesion is eradicated. This method often permits of removing regions of considerable expanse without producing distortion and leaves only a single fine line scar.

With wide involvement, especially adjacent to fixed points, such as about the nose and ears, free skin grafts or pedicle flaps usually are necessary for repair. The type of skin graft or flap best suited for the purpose will depend on the problems presented by the individual case. In general, free skin grafts are preferable to pedicle flaps about the face and neck when conditions permit of their use because of the saving of time, the shorter period of hospitalization required, and the more satisfactory cosmetic result. Gillies and McIndoe expressed their preference for the use of so called thick razor or split skin grafts in these cases but our own preference is for full thickness grafts, provided satisfactory skin is available and the rather definite contraindications to their use

Fig. 8. a, Squamous cell epithelioma (grade 2) originating in actinodermatitis resulting from treatment of goiter about 20 years previously; b, lateral thoracic flap used in correction; c, posterior end of flap transferred for repair; d, result following removal and repair.

Fig. 8c.

do not exist. When superficial ulceration and a good deal of inflammatory reaction are present the healing period can at times be shortened greatly by excision of the affected tissue and application of a thin shaved graft. Such grafts usually do well even in the presence of rather acute reaction. With healing complete, the inflammatory process subsides promptly, and the parts covered by the thin graft can then be re-covered with either a full thickness skin graft or a pedicle flap for improvement of its appearance or function.

Full thickness skin grafts possess greater body, are more resistant to trauma, contract very little, and as a rule present a better cosmetic appearance than thin grafts. They should not be used in the presence of infection or in areas that cannot be kept free from contamination and that cannot be immobilized. With these conditions under control, dissected grafts do very well indeed, although, as has been repeatedly emphasized, the technique of their application is very exacting. Lesions of considerable extent about the face and neck can be covered with a single graft of this type cut accurately to pattern, but, in some instances,

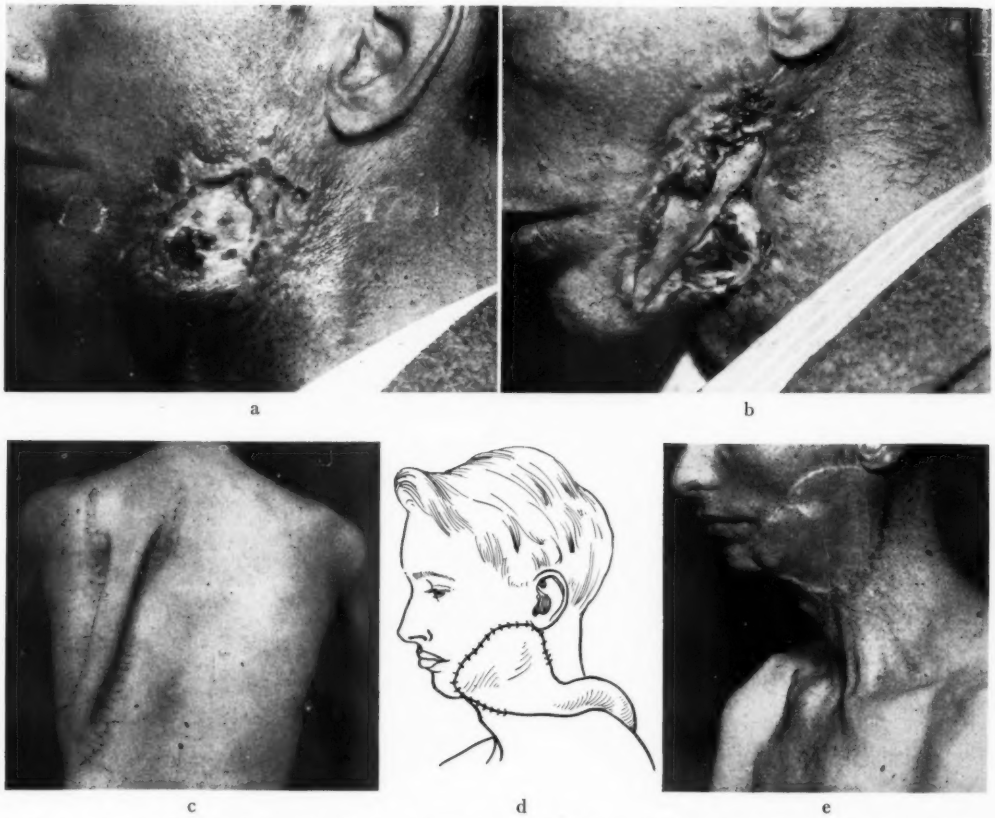

Fig. 9. a, and b, Radium dermatitis with sloughing and necrosis of bone from treatment of malignant tumor of mandible 8 years before; c, tubed back flap for correction; d, lower end of flap transferred for repair; e, result.

because of the difficulty of immobilization, it is preferable to apply grafts in such areas in stages. In addition this frequently offers a much better chance of a successful take. According to this plan a portion of the lesion is excised and a graft is applied to the wound. After healing is complete a portion or all of the remainder of the pathological tissue is taken care of in the same manner, and, if necessary, the process is repeated subsequently until eradication is complete. By immobilization of the mandible with interdental wiring or by other means, counterpressure is secured so that the application of large grafts about the cheeks and lips is feasible. So called split skin grafts and other thinner grafts removed with the dermatome can be applied to extensive wounds on the face or elsewhere about the body with an excellent chance of taking even in the presence of contamination. While such grafts contract a good deal and often are greatly wrinkled for a time, the ultimate cosmetic result as a rule is not displeasing.

With deeper involvement present, repair will require the use of some type of pedicle flap. The location, size, and form of this must be determined by the situation and extent of the involvement. In most instances the flap should be prepared in advance and removal of the lesion delayed until the former is ready for transfer. There is always the possibility of an error of judgment in this connection, and the region of radiodermatitis or the malignant process superimposed on it may prove more extensive than it had appeared on clinical examination, so that the flap will not be large enough to cover the defect. However, by shifting the adjacent tissues this usually can be compensated for. In any event it

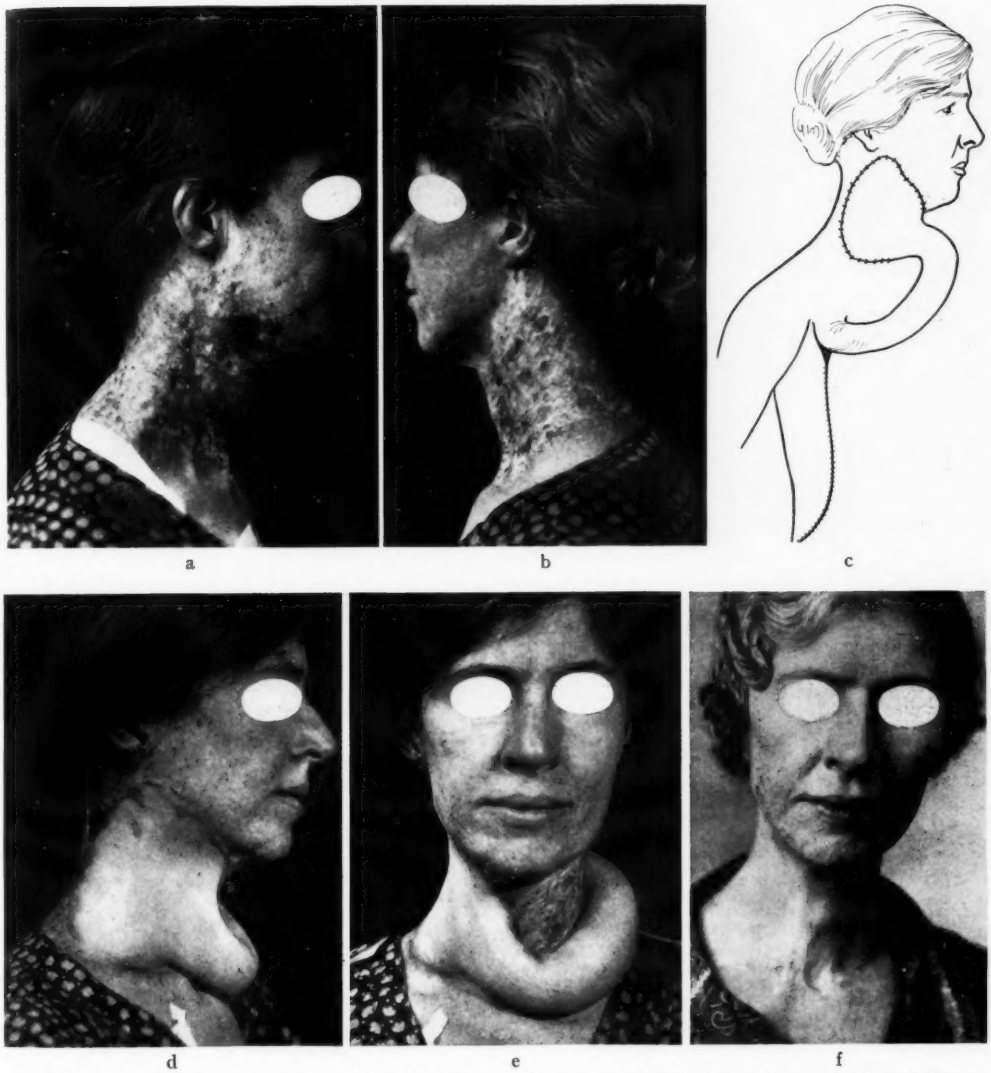

Fig. 10. a and b, Actinodermatitis involving the entire neck and the lower portion of the face resulting from treatment for scarring and excessive growth of hair in these regions 16 years previously; c, lower end of lateral thoracic flap transferred to neck; d and e, entire flap encircling the neck, being attached only at either end; f, result of repair.

always is advisable to make the flap appreciably larger than has appeared necessary.

Thick contaminated lesions in regions such as the base of the neck where the application of a free skin graft would leave an unsightly depression can be replaced satisfactorily at times with a double pedicle flap in a single stage. After removal of the affected tissue with a wide ellipse, a skin flap of sufficient width to cover the area is elevated at the lower border of the wound and left attached at both ends. This is shifted to cover the denuded region and sutured in place while a skin graft is applied to the site from which the flap was taken. The more conspicuous portion of

the repair is thus concealed by the patient's clothing. The same objective can be accomplished with a flap having a single pedicle, but a multiple stage procedure and so more time are required.

Various types of flaps from the forehead or temporofrontal region, that is, the oblique, transverse, and semicircular, serve ideally for repair following removal of regions of radiodermatitis involving the nose, cheeks, or upper lip. Preliminary skin grafting of the undersurface of such flaps permits of their use when sacrifice of the full thickness of any of these structures has been necessary. The repair can be carried out in a minimum of time because of the proximity and the vascularity of these tissues, and the end-result is highly satisfactory because of their color and texture. Use of such flaps is restricted largely to women, however, because of the conspicuous scarring left on the forehead. It is limited also by their size and the extent of their reach.

For correction of defects resulting from extensive radiodermatitis and necrosis about the lower portion of the face and neck, use of a tubed flap from some portion of the trunk is usually required, although at times we have employed a flat pedicle flap from the anterolateral aspect of the arm for the purpose. This latter form of flap possesses the advantage shared by the tubed flap of avoiding additional scarring on an exposed surface but the area from which it is removed cannot be sutured primarily and must be covered with a free skin graft. As a consequence the donor site is scarred rather badly. However, most of the female patients who have such lesions have already lost the desire to wear evening gowns, so that the scarring is of little consequence. Actually the flap possesses little advantage over tubed flaps except that it obviates scarring of the chest or back. The time requirement is somewhat shorter but the color is similar to that of flaps from the trunk. Many of the tubed flaps in women are obtained from the back and the skin in this situation is usually coarser than that on the arm.

The region from which a tubed flap is to be secured will depend on the situation and extent of the involvement. For a localized area about the lower part of the face and neck, an acromiosternal flap extending parallel to the clavicle and below it often is most satisfactory. The sternal attachment is transferred. This type of flap has a wide range of application because of the mobility of the shoulder. For more extensive lesions, flaps of this type extending vertically in the lateral thoracic region or transversely on the lower portion of the chest, one end of which may be swung directly to the involved region, or abdominal flaps transferred by attachment to the wrist are likely to be required. In a case in which radiodermatitis was taken care of some years ago involvement of the skin and subcutaneous tissue of the entire neck and lower portion of the face was present, and a lateral thoracic flap of sufficient length to encircle the neck was required.

The results of the surgical treatment of radiodermatitis in most instances are highly satisfactory as regards relieving the patient's symptoms, correcting existing deformity, and restoring function. The symptoms, which usually are trying and of long duration, are relieved almost at once on removal of the involved tissue. This is true even though the wound is not closed immediately. It is true also in cases in which malignant change has occurred. As there is comparatively little tendency for neoplasms developing as a result of radiodermatitis to metastasize until well advanced, an excellent chance of cure is afforded by wide removal in a reasonably early stage. Plastic correction is always one of the chief problems, and the result of repair will naturally vary with the features presented by the individual case and the experience of the surgeon.

Figures 1 to 10, inclusive, illustrate the conditions in various cases before operation, the operative methods used, and the results of operation.

SUMMARY

Radiodermatitis often is more serious than the condition for which treatment was given primarily. Overexposure during diagnostic or therapeutic procedures usually is responsible for such lesions but individual susceptibility is an important etiological factor. The acute stage of the disease is self-limiting unless excessive reaction is present, and surgical treatment is contraindicated during this period. The chronic stage of the process is progressive and there is a decided tendency for epithelioma to develop. Surgical removal is the only means of controlling the condition when secondary irradiation changes are pronounced. Primary closure of the wound is at times possible following excision of the region of radiodermatitis. When this is not feasible, application of a free skin graft or use of a sliding flap or a pedicle flap is required. The ultimate result in these cases as a rule is satisfactory.

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MALIGNANT TUMORS OF THE KIDNEY

Surgical and Prognostic Significance of Tumor Thrombosis of the Renal Vein

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THE prognostic significance of metastatic involvement of the regional lymph nodes in cases of carcinoma of the breast, stomach, or colon is well known. It is recognized that malignant tumors of the kidney have a tendency to invade the renal vessels. This is especially true of carcinoma of the renal cortex, which is commonly called "hypernephroma." In an occasional case the resulting thrombosis has extended into the inferior vena cava and in rare instances it has extended into the heart.

The recognition of a tumor thrombus in the renal vein in the presence of renal neoplasm is of importance from a surgical as well as a prognostic point of view. At the time of operation the surgeon always adheres to certain principles in mobilization of the growth because of the possible existence of a tumor thrombus. Furthermore, he determines as early as possible during the course of the operation whether or not such a thrombus actually exists. If it is found, certain special procedures must be employed in order to deal with it properly and thereby reduce the risk of operation and enhance the likelihood of ultimate survival of the patient.

Foulds observed involvement of the renal vein in 22.5 per cent of 200 cases of carcinoma of the kidney. Judd and Scholl reported a case of hypernephroma in which fatal pulmonary embolism occurred while nephrectomy was being performed. The source of the embolus was a thrombus in the renal vein. Of the few authors who appear to have recognized that involvement of the renal vein adversely affects the period of survival after operation in cases of malignant tumor of the kidney, we can mention Hand and Broders. They reported that the renal vein was involved in 38 or 19.6 per cent, of 193 cases of carcinoma of the renal cortex. The average period of survival after nephrectomy was 59 months in cases in which the renal vein was not involved whereas it was only 48 months in cases in which the renal vein was involved. The present report is based primarily upon a study of the incidence of this complication in the presence of renal neoplasm and its importance in the ultimate rate of survival following nephrectomy.

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METHOD OF STUDY

In order to determine the incidence of tumor thrombosis of the renal vein and the effect of such thrombosis on the ultimate survival rate after nephrectomy for malignant neoplasm, a dissection was made of the vein, artery, and their tributaries in the hilum of every kidney that had been removed because of a malignant neoplasm at the Mayo Clinic in the years 1904 to 1940 inclusive. In all, approximately 700 kidneys were examined. Of necessity a number of kidneys were so mutilated that structures in the hilum evaded identification. In other cases, only the tumor had been saved. These specimens were discarded from the series; therefore, 636 kidneys containing malignant neoplasms were included in this study. Only that portion of the renal vein and artery and their tributaries which lay outside the renal parenchyma was examined. No attention was accorded vascular involvement by malignant neoplasm within the kidney because the renal vein and artery rapidly lose their muscular tunics on entering the kidney, which makes their identification difficult and often highly questionable because of the liability of confusing vessels with artifacts. No attempt was made to investigate the accessory renal vessels as this was felt to be impractical. The gross examination of the vein and artery usually sufficed to indicate whether a tumor thrombus was present. If it was present, a block of tissue from the involved vessel was obtained from which a histological section was cut and stained with hematoxylin and eosin. When any doubt existed as to whether the vessels in the hilum were or were not involved, a block was cut from the doubtful vessel and a histological section was made. In every instance, histological sections of the tumor itself were examined. This was the procedure which was followed in regard to all malignant neoplasms of the kidney. Carcinomas of the renal pelvis required additional investigation.

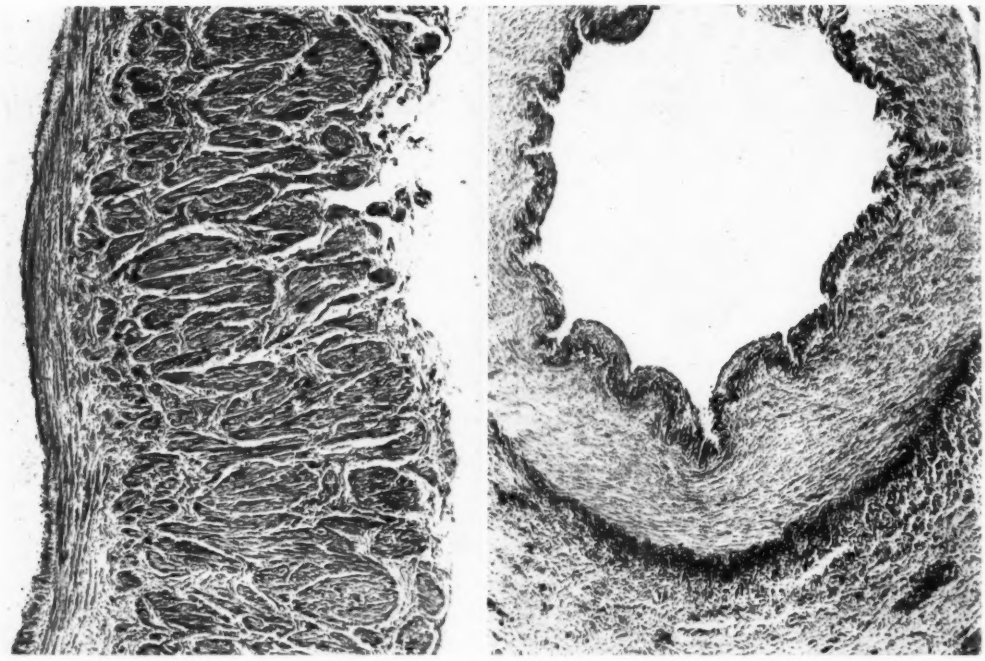

Fig. 1. a, left, Main renal vein; adjacent to the intima is a relatively insignificant layer of circular smooth muscle; exterior to this are well developed longitudinal bundles of smooth muscle (hematoxylin and eosin, ×33). b, Main renal artery showing the well developed internal and external elastic tissue lamina (hematoxylin and eosin, ×43).

The epithelium of the urinary bladder, ureter, and pelvis of the kidney is comparable in histological appearance as well as origin. It is a well known fact that carcinomas of the urinary bladder exhibit a predilection to metastasize by way of the lymphatics to the regional lymph nodes. There is no denying the fact that metastasis does take place through the vascular system to remote organs. It is to be expected that carcinoma of the renal pelvis arising from epithelium similar to that found in the urinary bladder would behave in a similar fashion and metastasize both by the lymphatics and blood vessels.

TABLE I.—INCIDENCE OF TUMOR THROMBOSIS OF RENAL VEIN AND INVOLVEMENT OF PERINEURAL LYMPHATICS IN 636 CASES OF MALIGNANT TUMORS OF THE KIDNEY

Type of tumor	Cases		Tumor thrombosis of renal vein or involvement of lymphatics or both	
	Number	Per cent	Number	Per cent
Hypernephroma	509	80.0	275*	54.0
Squamous cell carcinoma	76	11.9	34	44.7
Wilms' tumor	31	4.9	14†	45.2
Sarcoma	20	3.1	2‡	10.0
Total	636	99.9	325	51.1

*Perineural lymphatics involved in only 1 case.
†Perineural lymphatics involved in 2 cases.
‡Lymphatics not involved.

Blocks of tissue were cut from the hilum of every kidney showing a carcinoma of the renal pelvis and histological sections were made and examined. One block included the main renal artery and adjacent tissue. This was done because it was found that the perineural lymphatics in the hilum were frequently involved in kidneys affected with squamous cell carcinoma of the pelvis and one of the surest and easiest places to identify lymphatics in the hilum of the kidney is immediately adjacent to the nerves. Nerves constantly have a lymphatic sheath around them. For this reason, in studying the metastasis of malignant neoplasms of the kidney by way of the lymphatics, those around the nerves were chosen as being most

Fig. 2. Gross appearance of the hilum of the kidney. The main renal vein and the main renal artery are evident. The renal vein is widely dilated and filled with a malignant thrombus. The primary neoplasm of the kidney is a hypernephroma.

Fig. 3. Gross appearance of hilum of kidney. As in Figure 2, the main renal vein and artery are evident; the renal vein is widely dilated and filled with a malignant thrombus, and the primary neoplasm is a hypernephroma

readily identifiable. Thus all guesswork as to whether one was dealing with lymphatics or artifacts was eliminated. The region around the renal artery was particularly advantageous for the study of the nerves because of their abundance in this region. Of necessity, involvement of the perineural lymphatics is not a gross but rather a histologic observation.

Under ordinary circumstances, the identification of the main renal artery and renal vein was easy. The lumen of the vein is two or three times the size of that of the artery. The wall is thinner and more collapsible than the wall of the artery. Anatomically, the vein is situated characteristically in the anterior portion of the hilum, the artery somewhat more posteriorly, and the ureter with its pelvis more posteriorly still. There is considerable fat between the structures in the hilum of the kidney. The renal nerves in the hilum accompany the arteries. Histologically, the main renal vein is characterized by having an insignificant, circular, smooth muscular tunic adjacent to the intima while external to this is a very prominent longitudinal smooth muscle coat with the muscle fibers arranged in bundles (Fig. 1a). The histological appearance of the wall of the renal vein is very similar to that of the inferior vena cava. The renal artery does not differ from any other medium sized artery having a well formed internal and external elastic tissue lamina (Fig. 1b). The renal nerves are of the nonmyelinated variety and easy to identify.

The identification and determination by gross and histological methods of the presence or absence of a malignant neoplasm in that portion of the renal vein, artery or perineural lymphatics situated outside the renal parenchyma was determined in the 636 cases. In not a solitary case was the outcome known to the investigators during the study. In this way there was no opportunity for even an unconscious effort to find involvement of the renal vessels in those cases in which the patients lived a short time, or vice versa, after nephrectomy. All malignant neoplasms were classified and graded at the same time. At the conclusion, the survival rates were tabulated by the Division of Biometry and Medical Statistics.

A few words might be added about the terms used. We have chosen to use the term "hypernephroma" as being synonymous with carcinoma of the renal cortex. It is the general consensus that practically all, if not all, of these neoplasms

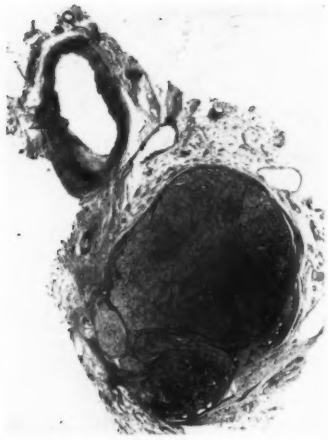

Fig. 4. Section of main renal vein and main renal artery. The artery shows no evidence of thrombosis; the vein, however, is filled with a malignant thrombus secondary to a hypernephroma of the kidney (hematoxylin and eosin ×39).

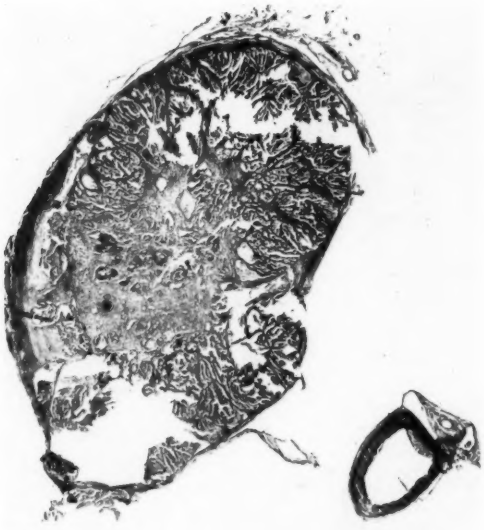

Fig. 5. Section of main renal vein and renal artery. The renal vein is widely dilated and filled with a malignant thrombus secondary to hypernephroma of the kidney (hematoxylin and eosin ×39). Size of the vein should be compared with that in Figure 4.

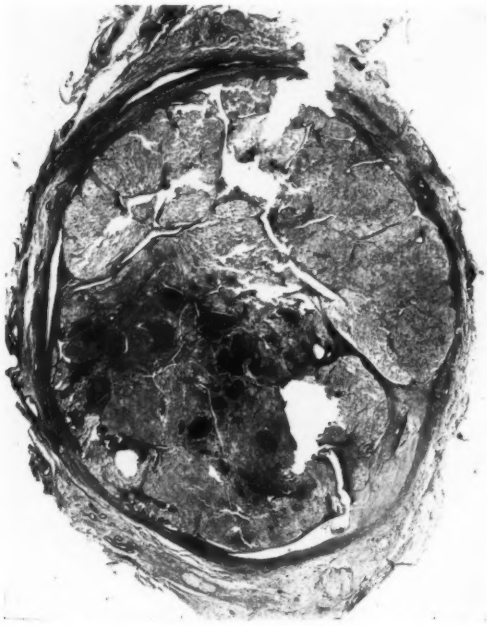

Fig. 6. Section of main renal vein. Primary tumor is a hypernephroma of the kidney. The vein is widely dilated and filled with hypernephroma (hematoxylin and eosin ×3+).

originate from renal tubules rather than adrenal rests. There is still considerable controversy as to the fate of so called adenoma of the cortex of the kidney. It is our opinion that this represents an early adenocarcinoma of the renal cortex. However, this neoplasm apparently has little or no tendency to metastasize until it reaches a certain size. It was decided not to include this controversial neoplasm in this study of hypernephromas; consequently, only carcinomas of the renal cortex which were more than 3 centimeters in diameter were included. Carcinomas of the renal pelvis are referred to as "squamous cell carcinomas" because carcinomas of this type often tend to differentiate into real squamous epithelium including keratinization. Wilms' tumor is commonly referred to as "embryoma." The sarcomas represent a heterologous group. In this group are included lymphosarcoma, fibrosarcoma, and leiomyosarcoma.

INCIDENCE AND PROGNOSTIC SIGNIFICANCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

The type of malignant tumors encountered in these 636 cases is shown in Table I. It is of interest to note that in 509, or 80 per cent, of the cases the tumor was classified as a hypernephro

Fig. 7. a and b, Section of main renal vein in 2 cases showing nubbin of hypernephroma only partly occluding vein and producing no evidence of complete thrombosis. The firm attachment to intima of vein may be noted. The primary tumor in each was a hypernephroma of the kidney (hematoxylin and eosin; a, ×10.4; b, ×34).

ma. The relative incidence of the various tumors varies in minor degree from that reported by Priestley in 1939, but, as has been stated previously, it was necessary in this study to eliminate certain neoplasms because the hilum of the kidney could not be identified; in addition, those malignant neoplasms of the kidney which were removed in the years 1937 to 1940 inclusive are included in this study. For statistical purposes in computing the survival rate, only the patients who were operated on prior to January 1, 1937, were included. This was done so that all the patients

TABLE II.—MALIGNANT TUMORS OF THE KIDNEY: RELATION OF 5 YEAR SURVIVAL RATE TO PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN OR INVOLVEMENT OF THE PERINEURAL LYMPHATICS OR BOTH

	Hypernephroma				Squamous cell carcinoma			
	Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital		Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
No involvement of renal vein or lymphatics	189	186	103	55.4	35	35	15	42.9
Involvement of renal vein and lymphatics	213	207	60	29.0	22	21	1	4.8
Total	402	393	163	41.5	57	56	16	28.6

*Inquiry as of January 1, 1942. Included here are patients operated on 5 or more years prior to the time of inquiry, that is, 1936 or earlier. Hospital mortality is excluded in the calculation of survival rates.

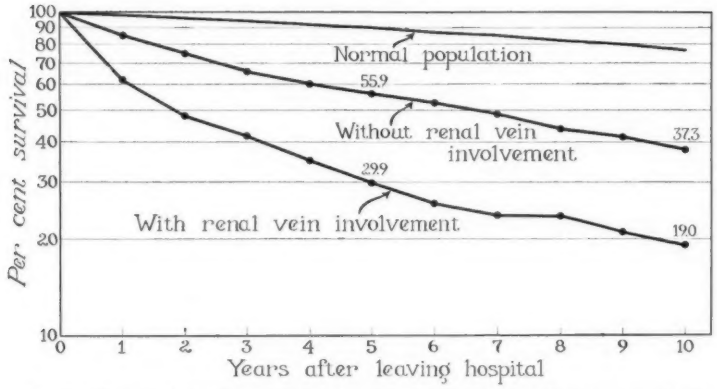

Fig. 8. The survival rates in cases of hypernephroma of the kidney compared with that of the normal population of the same average age as that of the patients with hypernephroma. Curves are plotted on the logarithmic scale.

would have been operated on a sufficient number of years prior to the investigation. Operative deaths and the cases of those patients who could not be traced were not considered in calculating the survival rate.

As might be expected, the hospital mortality rate was slightly higher in cases in which tumor thrombosis was found in the renal vein (8 per cent) than it was in cases in which such thrombosis was not present (6.1 per cent). This can readily be explained by the fact that hemostasis is more difficult to obtain in cases in which thrombosis is present. In addition, a thrombus in the renal vein occasionally may break loose at the time of surgical manipulation and cause pulmonary embolism.

HYPERNEPHROMA

In 509 of the 636 cases, the renal tumor was a hypernephroma (Table I). Malignant thrombosis of the renal vein (Figs. 2 and 3) was present in 275, or 54 per cent, of the cases of hypernephroma. It is worthy of repetition that in this paper the term "renal vein" has been used to designate one of the veins in the hilum of the kidney, in most cases, the main renal vein or one of its primary divisions. There was no evidence of neoplastic involvement of an artery in any of the cases of hypernephroma. In a number of cases, histological examination disclosed endarteritis of the main renal artery occasionally with benign thrombosis but neoplastic involvement could not be demonstrated. Involvement of the perineural lymphatics was observed in only 1 case. Tumor thrombosis of the renal vein also was present in this case.

The neoplastic cells apparently enter the venules in the region of the tumor and invade the larger veins by continuity. No other carcinoma exhibits this tendency to such a marked degree. That the arterial tree is not invaded is best

TABLE III.—HYPERNEPHROMA OF THE KIDNEY: RELATION OF 5 YEAR SURVIVAL RATE TO GRADE OF MALIGNANCY AND THE PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

Malignancy	No involvement of renal vein				Tumor thrombosis of renal vein			
	Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital		Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
Grade 1 or 2	149	146	86	58.9	148	143	52	36.4
Grade 3 or 4	40	40	17	42.5	65	64	8	12.5
Total	189	186	103	55.4	213	207	60	29.0

*Inquiry as of January 1, 1942. Included here are patients operated on 5 or more years prior to the time of inquiry, that is, 1936 or earlier. Hospital mortality is excluded in the calculation of survival rates.

explained by the fact that the arterioles unlike venules have a more definite wall which is probably sufficient to prevent carcinoma cells from entering the arterioles. It is not surprising that the lung is the usual site of metastatic involvement in cases of hypernephroma. This may be explained by the lack of lymphatic involvement in the hilum of the kidney and by the relative absence of metastatic involvement of the regional lymph nodes. Bizarre metastatic involvement of the spinal column can readily be explained by anastomosis of the renal veins with those of the paravertebral venous system, which has been described by Batson. In cases in which thrombosis of the main renal vein is present, the vein may be normal in size but it usually is dilated (Figs. 4 and 5); in some cases, the diameter of the lumen may be increased ten times (Fig. 6). The thrombosis may extend a varying distance along the renal vein; at times, it even may involve the inferior vena cava. It becomes firmly attached to the intima of the vein as it grows (Figs. 7a and b). It acquires its blood supply from the wall of the vessel as it grows, and thus behaves as a sort of parasite. This is a very important phenomenon to recognize as when a tumor thrombus is present in a renal vein it is not sufficient for the surgeon to "milk" the thrombus in the vein toward the kidney and then cut the vein where the thrombus was originally attached. By so doing, neoplasm will inevitably be left attached to the wall of the remnant of the renal vein. It is necessary to excise the vein beyond the site of attachment of the thrombus, that is, on the side of the vena cava.

In the cases of hypernephroma, the mortality rates in the first year after the patients were dismissed from the hospital were as follows: 38 per cent in the cases in which tumor thrombosis of the renal vein was present at the time of operation and only 18 per cent in the cases in which tumor thrombosis was not present. This is another indication that tumor thrombosis of the renal vein seriously affects the prognosis in cases of hypernephroma. The 5 year survival rate in both groups of cases was 41.5 per cent (Table II). It is of interest to note that it was 55.4 per cent in cases in which tumor thrombosis of the renal veins was not encountered at operation and only 29 per cent in cases in which thrombosis was not present. The survival rates are shown graphically in Figure 8.

In the cases in which tumor thrombosis was present, it seems reasonable to assume that showers of malignant emboli must have occurred into the venous circulation and especially in the lungs. It is a wonder that actual metastatic lesions were not present in the lungs in all of these cases. It is apparent that few of these emboli acquires a parasitic blood supply and those that do live occasionally undergo regression after removal of the primary neoplasm.

The relation of tumor thrombosis of the renal vein and the grade of malignancy, as determined by the method of Broders, is shown in Table III. Tumor thrombosis was present in 49.8 per cent of the cases in which the hypernephroma was grade 1 or 2 and in 61.9 per cent of the cases in which the tumor was grade 3 or 4. It is apparent, therefore, that even hypernephromas of low grade have a great tendency to invade the renal vein. Table III reveals that the presence of tumor thrombosis of the renal vein tends to increase the gravity of the prognosis regardless of the grade of the primary tumor.

Table IV shows the relation of tumor thrombosis of the renal vein to the weight of the involved kidney, that is, the weight of the kidney and the hypernephroma. The incidence of tumor throm-

TABLE IV.—HYPERNEPHROMA OF THE KIDNEY: RELATION OF 5 YEAR SURVIVAL RATE TO THE WEIGHT OF THE INVOLVED KIDNEY AND THE PRESENCE OF TUMOR THROMBOSIS OF THE RENAL VEIN

Weight of involved kidney, grams	No involvement of renal vein				Tumor thrombosis of renal vein			
	Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital		Patients who survived operation*		Patients who lived 5 or more years after dismissal from hospital	
	Total	Number traced	Number	Percentage of traced patients	Total	Number traced	Number	Percentage of traced patients
0 to 499	66	65	35	53.8	45	45	15	33.3
500 to 999	56	55	30	54.5	80	76	20	26.3
1000+	28	28	13	46.4	48	48	9	18.7

*Inquiry as of January 1, 1942. Included here are patients operated on 5 or more years prior to the time of inquiry, that is, 1936 or earlier. Hospital mortality is excluded in the calculation of survival rates.

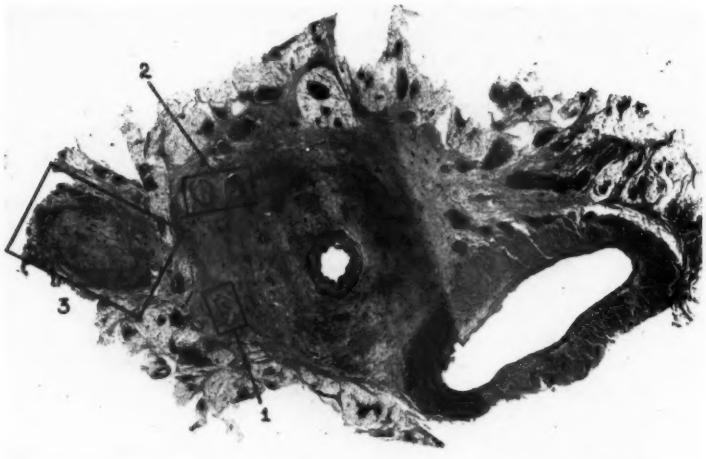

Fig. 9. Hilum of the kidney removed surgically for carcinoma originating in renal pelvis. The main renal artery in center of hilum and main renal vein which had a larger lumen than the artery are uninvolved (hematoxylin and eosin ×3.8). Areas *1*, *2*, and *3* shown under higher magnification in Figures 10, 11a and b respectively.

Fig. 10. Carcinoma of the pelvis of the kidney. Section from hilum of kidney, shown in Figure 9, area *1*. The lymphatics surrounding the nerve are filled with carcinoma cells. The carcinoma cells have produced a pseudoalveolar effect (hematoxylin and eosin ×70.8).

bosis according to the weight of the involved kidney was as follows: 40.6 per cent in cases in which the involved kidney weighed less than 500 grams, 58.8 per cent in cases in which it weighed 500 to 999 grams and 63.1 per cent in cases in which it weighed 1,000 grams or more. It was found that the incidence of tumor thrombosis of the renal vein increased slightly with the weight of the involved kidney. Table IV also shows the 5 year survival rate according to the weight of the involved kidney and the presence or absence of tumor thrombosis of the renal vein.

Infarction of a portion of the tumor in the kidney is a very common manifestation of hypernephromas. Usually, hemorrhage accompanies this phenomenon as it does infarction which occurs elsewhere in the body. It would appear likely that such infarction is the result of thrombosis of the veins.

CARCINOMA OF THE RENAL PELVIS

In 76, or 11.9 per cent, of the entire series of cases of malignant tumor of the kidney, the neoplasm was a carcinoma of the renal pelvis (Table I). Involvement of the perineural lymphatics in the hilum of the kidney or tumor thrombosis of the renal vein or both were present in 34, or 44.7 per cent, of the cases of carcinoma of the renal pelvis (Table I). Thrombosis of the main renal vein or of one of its smaller branches in the hilum of the kidney was present in 31 of the 34

cases. Involvement of the perineural lymphatics in the hilum of the kidney (Figs. 9, 10 and 11a) was present in 23 of the 34 cases. Tumor thrombosis of the renal vein (Figs. 11a and b and 12a) was present in 20 or 86.9 per cent, of the 23 cases in which there was involvement of the perineural lymphatics. In one of the 20 cases, thrombosis of the renal artery also was present (Fig. 12b).

Because the lymph and blood vessels of the hilum of the kidney are so close to the epithelium of the renal pelvis, it is not surprising that tumor thrombosis of the renal vein and involvement of the perineural lymphatics are rather common in cases of carcinoma of the renal pelvis. It is more surprising that they are not encountered more frequently. In cases of carcinoma of the renal pelvis, metastasis usually occurs in the periaortic lymph nodes or in the lungs.

The 5 year survival rate is shown in Table II. In cases in which tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both were present, only 1 patient is known to be alive 5 years after dismissal from the hospital.

WILMS' TUMOR

Tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both were present in 14, or 45.2 per cent, of the cases of Wilms' tumor (Table I). The perineural lymphatics were involved in 2 cases. Tumor thrombosis of the renal vein also was present in 1 of these cases. Considerable necrosis was observed in 2 of the cases in which tumor thrombosis of the renal vein was present. In these cases, radiotherapy apparently had produced necrosis of the tumor thrombus. The presence of tumor thrombosis of the renal vein or involvement of the perineural lymphatics or both apparently had little influence on the 5 year survival rate in the cases of Wilms' tumor.

SARCOMA

Tumor thrombosis of the renal vein was present in 2 of the 20 cases of sarcoma of the kidney

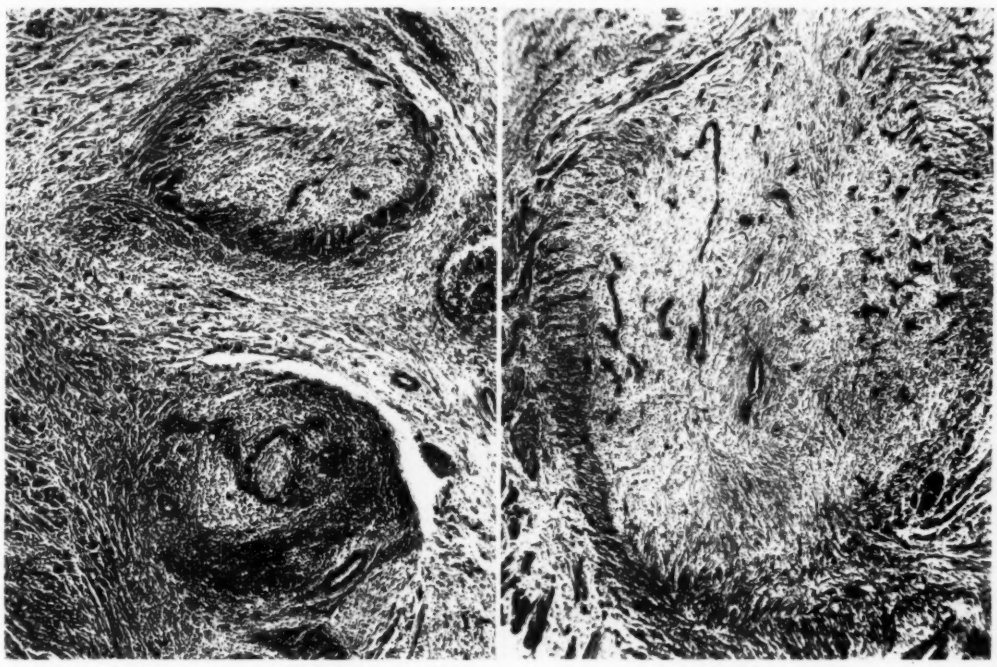

Fig. 11. Carcinoma of pelvis of kidney. a, left, A small vein and nerve in the hilum of the kidney taken from area 2 in Figure 9. The vein is completely thrombosed showing much fibrous tissue and a few strands of squamous cell carcinoma (hematoxylin and eosin ×39). The lymphatics around the nerve are sheathed with carcinoma cells. b, A larger vein taken from area 3 in Figure 9. Its muscular walls are completely thrombosed with fibrous tissue containing a few strands of carcinoma cells (hematoxylin and eosin ×24).

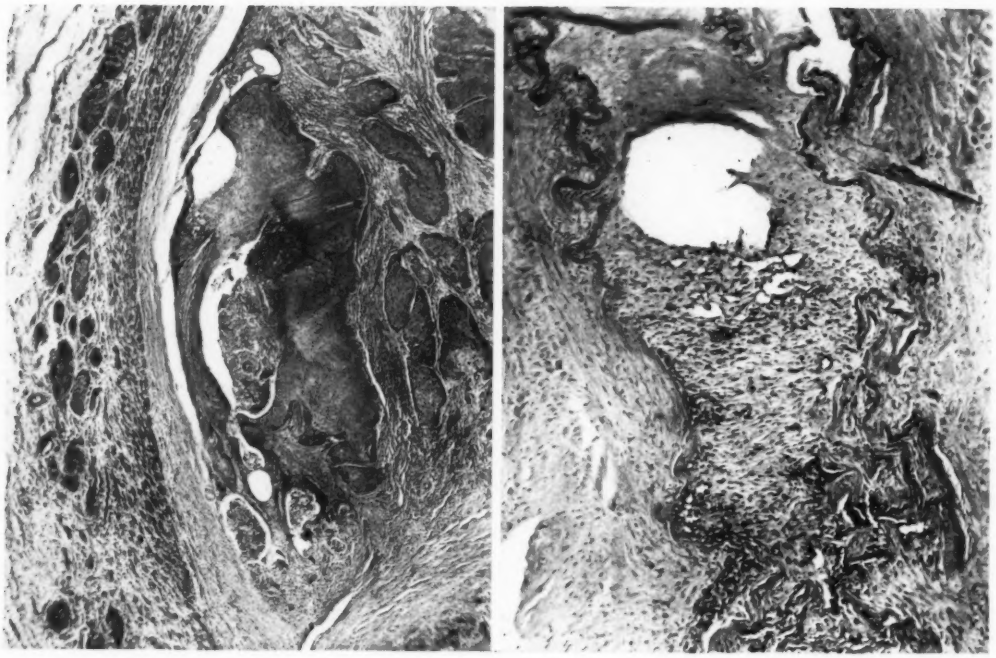

Fig. 12. a, left, Section of main renal vein taken from a kidney removed surgically for squamous cell carcinoma of the renal pelvis. The vein is thrombosed and the squamous cell carcinoma is evident within the lumen of the vein (hematoxylin and eosin ×24). b, An artery demonstrating the internal elastic lamina, completely thrombosed with fibrous tissue in which are evident a few strands of carcinoma. The primary neoplasm in this instance was a squamous cell carcinoma of the renal pelvis (hematoxylin and eosin ×56).

(Table I). Involvement of the perineural lymphatics was not encountered in any of these cases. In cases of sarcoma of the kidney, the presence of thrombosis of the renal vein did not appear to be of prognostic significance.

SURGICAL CONSIDERATION

From the surgeon's point of view, as mentioned previously, it is always important to bear in mind the possibility of involvement of the renal vein by a thrombus composed of tumor tissue, when undertaking the removal of a malignant renal neoplasm. If one handles the kidney too roughly or injures it unnecessarily in any manner it is entirely possible that a portion of such a tumor thrombus may be broken loose and enter the vena cava. Under these circumstances the patient receives a direct intravenous injection of viable tumor cells which would be expected to give rise to metastatic lesions. It seems quite likely that, in certain cases, metastatic pulmonary lesions which become apparent soon after nephrectomy for malignant neoplasms of the kidney may be accounted for in this manner.

In order, then, to avoid breaking loose a possible tumor thrombus in the renal vein, the surgeon always handles a renal neoplasm as gently as possible. It is compressed, pulled on and normally manipulated in any other manner to a minimal degree. As soon as possible during the course of the operation the surgeon identifies and isolates the renal pedicle. For the purpose of gaining more rapid access to the renal pedicle, some surgeons have advocated a transperitoneal approach for the removal of a renal neoplasm. It has not been our experience that this approach is of particular value unless one is dealing with a tumor of exceptional size. Rapid mobilization of the kidney is facilitated by more or less disregarding the enlarged veins which may surround the kidney as bleeding from them will be almost completely controlled when the renal pedicle is secured.

After satisfactory exposure of the pedicle, the surgeon first determines by palpation of the renal

vein, as he can in most cases, whether or not a tumor thrombus is present in this vessel. If none is found, clamps may be applied promptly in an appropriate manner to the renal pedicle, and the kidney may be removed. If a tumor thrombus is found it will have to be dealt with in one of several ways, depending on its size and the degree of involvement of adjacent structures. It should be remembered, as will be mentioned later in more detail, that the wall of the vein becomes involved by the malignant process in the presence of a tumor thrombus. This means that the portion of the vein to which the thrombus is attached also must be removed if all tumor tissue is to be removed. Usually, however, there is a short projection of the thrombus centrally in the vein beyond the most proximal point of attachment to the wall of the vein.

The easiest type of tumor thrombus to deal with is the one which extends for such a short distance in the renal vein that there is enough uninvolved portion of the renal vein for the application of clamps between the thrombus and the vena cava. Such a case offers no particular problem except that care should always be taken not to dislodge the thrombus and not to include any of it in the clamps. In other cases it may be found that the thrombus extends almost to the vena cava so that there is space for the application of one clamp only between the end of the thrombus and vena cava. Under these circumstances this clamp should be applied to the renal vein and the tumor removed. Any involved portion of the renal vein distal to the clamp may then be excised and the remaining portion may be utilized for obtaining hemostasis either by ligature or suture. When circumstances are unfavorable because of difficulty of exposure, poor condition of the patient or other reason, one or more clamps may be left in place on the renal vein with safety. These are loosened in 48 hours and removed in 72 hours. Fortunately, the renal artery in cases of hypernephroma is practically never involved with tumor thrombus and, therefore, the arterial blood supply to the kidney may be controlled in the usual manner.

In the event that the tumor thrombus extends from the renal vein into the vena cava, a more serious and difficult problem is presented. When this occurs on the left side it is seldom if ever that all involved tissues can be removed. If involvement of this type is found on the right side, where the vena cava is more accessible, the extension of the tumor into the vena cava usually can be removed unless it is too massive. In case there is a relatively small extension into the vena cava one may be able to expose this vessel above and below the region of involvement. The flow of blood in the vena cava then is controlled in one of several ways. The assistant may compress the vessel against the vertebral column with one finger placed above and one finger below the site of the thrombus, or rubber covered Doyen forceps or a serrefine clamp may be placed in similar positions. The surgeon then opens the vena cava, removes the thrombus, and any of the wall of the vena cava that is involved. After removal of the tumor thrombus and while hemostasis is maintained, the vessel is sutured with a single row of oiled silk blood vessel suture material. Removal of such a thrombus will make the difference between certain failure and at least the possibility of a satisfactory ultimate result. Of course, in some cases it may be impossible to remove thrombotic extension into the vena cava, particularly if this is quite extensive and perhaps has extended both proximally and distally in the vein.

COMMENT

In cases of hypernephroma of the kidney, the presence of tumor thrombosis of the renal vein is of definite prognostic significance. The prognostic significance is comparable to that of involvement of the lymph nodes in cases of carcinoma of the breast or gastrointestinal tract. The main veins in the hilum of the kidney can be examined more easily and more quickly than can a group of lymph nodes. Five or ten seconds usually is sufficient to determine the state of the renal vein and its tributaries.

In cases of carcinoma of the renal pelvis, the prognostic significance of tumor thrombosis of the renal vein or involvement of the lymphatics is greater than it is in cases of hypernephroma. Involvement of the lymphatics can usually be determined only by histological examination. The lymphatics about the nerves can be identified most readily.

In addition to the grade of malignancy as determined by the method of Broders and the presence of tumor thrombosis of the renal vein or involvement of the lymphatics, there are other factors that obviously affect the prognosis. The most significant of these factors is involvement of the perirenal fat or structures adjacent to the kidney. In this study, the perirenal structures were not examined as the specimens had been fixed with formaldehyde. In some cases, the specimens had been fixed 40 years before this study was made. It, therefore, was our opinion that the results of examination of the perirenal structures would be inaccurate. When it is a

case of fresh specimens, it is not difficult to determine whether or not perirenal involvement is present.

It would appear that Wilms' tumor and sarcoma of the kidney metastasize by way of the blood vessels. In many of the cases, there is no involvement of the main renal vein. Neoplastic cells apparently enter the vessels in the kidney and metastasize from this point.

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CONGENITAL DISLOCATION OF THE HIP WITH SPECIAL ATTENTION TO THE AFTER-CARE PERIOD AND LATE POSTREDUCTIVE RESULTS

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ALTHOUGH congenital dislocation of the hip was recorded in ancient times, its pathological anatomy was not dealt with until the work of Paletta in 1820, and then carefully described by Dupuytren in 1826 (Tubby, 1929). Throughout the following years, the literature has been generously supplied with the clinical aspects of the congenital hip.

Like most orthopedic problems, congenital dislocation of the hip requires as careful and thorough attention to details in the after-care period as that given during the operative phase. Although each case presents an individual problem, certain basic principles must still be followed even though radically modified to suit both the patient and surgeon. These principles were carefully noted and their merits studied in a series of cases collected both in England and the United States. Of the 48 cases in this series which were treated and then, except for 2 cases, observed for 10 years or more, the majority were examined personally by the writer and the functional and anatomical end-results were recorded.

Congenital dislocation of the hip, a clinical entity that might better be expressed as congenital misplacement of the hip, for its etiology is still largely a matter of conjecture and theory, is not a rare deformity. It is observed more frequently in certain sections of the United States, particularly in the northern states. Outside of the Western Hemisphere, the largest incidence occurs in Italy and France, and at the Rizzoli Institute in Bologna, 3,216 cases had been treated in 33 years (Putti, 1934).

To evaluate the end-result after treatment of congenital dislocation of the hip, careful consideration has been given to the method employed to obtain the reduction, the position and period of immobilization, and complications that might have influenced the final result. Unfortunately, many of the case records were lacking in fine detail but all available data were obtained from them and reproduction of all roentgenographs on each case was made for the purpose of further study.

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Indebtedness and appreciation for the privilege of collecting and use of their cases, is expressed to Mr. Harry Platt, Manchester Royal Infirmary, England; Dr. Philip D. Wilson, Hospital for Special Surgery, New York City; and Drs. Lord, Schrock, and Johnson, Omaha, Nebraska.

METHODS OF REDUCTION

The closed method of reduction for congenital dislocation of the hip is used for the majority of patients treated in the clinics from which this series was collected and studied. Forty-four of the 48 cases in this group were treated by the closed manipulative method, and the technique described by Lorenz was followed in 41 of these 44 cases. In accordance with the teachings of Lorenz, the present writer was assured in the clinics from which the case records and patients were studied, that the hips were manipulated gently and without undue force. The procedures of Lange, Calot, and Ridlon were used for the 3 remaining patients treated by the closed method, Cases 27, 40, and 43, respectively (Table II).

Open operation was performed in only 4 patients in the entire series. Two hips, Cases 29 and 39, were reduced following the removal of a capsular obstruction but the third, Case 34, required remolding of the femoral head before reduction could be accomplished. The remaining case had a shelf constructed over the false acetabulum without an attempt to replace the femoral head in its normal position (Case 26).

IMMOBILIZATION

The position of immobilization of the hip following reduction by the Lorenz method was that of marked abduction, flexion, and external rotation. The "frog-leg" position of 90 degrees, abduction, 90 degrees, flexion, and marked external rotation was used in all cases in which patients were treated by the closed method, except Case 27 in which the leg was immobilized in abduction, extension, and internal rotation. The "frog-leg" or first position was maintained for a period varying from 1 month in Cases 20, 25, 30, 33, 36, and 39 as a minimum to a maximum of 10 months in Case 45, with an average of approximately 4 months (Table I).

TABLE I

Case number	Technique of reduction	First position (abduction-flexion)	Months of immobilization	Second position (abduction-flexion)	Months of immobilization	Third position (abduction-flexion)	Months of immobilization	Antetorsion requiring special treatment
1	Lorenz	90–90	4	Yes	4	45–30	1	None
2	Lorenz	90–90	6	60–45	3½	20–45	1½	None
3	Lorenz	90–90	14	60–60	16	No		None
4	Lorenz	90–90	6	60–45	5	No		None
5	Lorenz	90–90	2	60–45	3	20–45	3	None
6	Lorenz	90–90	7	70–70	4	Yes	4	None
7	Lorenz	90–90	5	Yes	4	No		None
8	Lorenz	90–90	3	70–45	3	50–	1	None
9	Lorenz	90–90	8	No				None
10	Lorenz	90–90	5½	Yes	6½	Yes	1	None
11	Lorenz	90–90	8	60–45	4	No		None
12	Lorenz	90–90	6	Yes	3	No		None
13	Lorenz	90–90	4½	70–	5	10–	2½	None
14	Lorenz	90–90	3	Yes	3	Yes	4	None
15	Lorenz	90–90	3	Yes	3	Yes	2	None
16	Lorenz	90–90	6	60–45	6	Yes	3	None
17	Lorenz	90–90	4	80–	5	No		None
18	Lorenz	90–90	6	Yes	5	No		None
19	Lorenz	90–90	4	30–	2	No		None
20	Lorenz	90–90	1	Yes	8	No		None
21	Lorenz	90–90	2	Yes	4	No		None
22	Lorenz	90–90	2	Yes	1	50–	6	Supracondylar osteoclasis at 7th month
23	Lorenz	90–90	2	Yes	1	Yes	3	None
24	Lorenz	Extreme abduction	2	Yes	2	Yes	3	Supracondylar osteoclasis at 4th month
25	Lorenz	90–90	1	Yes	2	Yes	3	Supracondylar osteoclasis in 3rd position
26	Open	Yes	3	No				None
27	Lange	Internal rotation	2	External rotation	1	No		None
28	Lorenz	90–90	4½	45–	3½	No		None
29	Open	20–	8	No				None
30	Lorenz	90–90	1	Yes	4	20–	2	Supracondylar osteoclasis in 2nd position
31	Lorenz	Axillary abduction	2	80–	2	20–20	8	None
32	Lorenz	90–90	3	Yes	3	No		None
33	Lorenz	90–90	1	25–	6	No		Supracondylar osteoclasis at 5 months
34	Open	90–90	2	Yes	1	No		None
35	Lorenz	20–	2½	Yes	4½	No.		None

TABLE I.—Concluded

Case number	Technique of reduction	First position (abduction-flexion)	Months of immobilization	Second position (abduction-flexion)	Months of immobilization	Third position (abduction-flexion)	Months of immobilization	Antetorsion requiring special treatment
36	Lorenz	90–90	1	Yes	11	No		None
37	Lorenz	90–90	3	Yes	3	No		None
38	Lorenz	90–90	3	Yes	2	Yes	2	None
39	Open	80–80	2	Yes	3	No		None
40	Calot	90–90	4	Yes	3	Yes	8	None
41	Lorenz	90–90	2	Yes	2	Yes	3	None
42	Lorenz	90–90	4	Yes	3	Yes	5	None
43	Ridlon	Yes	4	Yes	5	Yes	7	None
44	Lorenz	90–90	3	Yes	5	No		None
45	Lorenz	90–90	10	Yes	1	Yes	2	None
46	Lorenz	90–90	7	Yes	2	No		None
47	Lorenz	90–90	6	Yes	5	No		None
48	Lorenz	90–90	2	Yes	5	Yes	4	None

The Lorenz second position of less abduction, less flexion, and slight internal rotation was used in all patients treated by the closed method, except Cases 9 and 27. Although the second position is sometimes gradually obtained over a period of several days by means of skin traction pulling in the appropriate directions, in the present series the position was secured at the time of change of plaster either with or without anesthesia. The exact position of the hip in the second position was not described in detail in the records of most cases but when present, an attitude of approximately 60 degrees of abduction and 45 degrees of flexion was indicated most frequently. This position was also maintained approximately 4 months (3.8 months). Although a second position was used in all but 1 case, Case 9, a third position of still less abduction, less flexion, and increased internal rotation was used in only 24 of the 44 patients treated by the closed method.

ANTETORSION

The problem of antetorsion of the femoral neck has received considerable attention in numerous clinics when the stability of the reduced congenital hip is under consideration. In the newborn, the degree of antetorsion has been described by Bohm and, although the transcondylar diameter is at 15 degrees to the frontal plane and the head at 45 degrees to the same plane in the average case, this torsion may be considerably greater in the congenital dislocated hip. In only 5 of the 63 hips that are included in this paper was correction of

TABLE II.

Case number	Sex	Unilateral or bilateral	Age at beginning treatment—yrs.	Method of reduction	Period of immobilization—mos.	Clinical end-result	X-ray classification (Fairbank)	Time under observation—years
1	F	B	5	Closed	9	Good	R. C 2 L. C 2	16
2	F	U	2	Closed	11	Excellent	L. C 1	15
3	F	B	2	Closed	30	Fair	R. AR 2 L. AR 2	12
4	F	B	2	Closed	11	Good	R. AR 2 L. C 2	11
5	F	B	3	Closed	8	Fair	R. C 1 L. C 2	18
6	F	U	2½	Closed	15	Excellent	L. C 1	12
7	F	U	3	Closed	9	Excellent	L. C 1	11
8	F	U	11	Closed	7	Fair	R. AR 2	17
9	F	U	2	Closed	8	Excellent	L. C 1	11
10	F	U	2	Closed	13	Good	R. AR 1	11
11	F	U	6	Closed	12	Fair	L. C 2	10
12	M	U	6	Closed	9	Good	L. C 1	10
13	F	U	2	Closed	12	Good	R. C 1	12
14	F	U	5	Closed	10	Fair	L. AR 2	16
15	F	B	7	Closed	8	Good	R. AR 2 L. C 2	15
16	F	B	3	Closed	15	Good	R. C 1 L. AR 2	10
17	F	U	2	Closed	9	Excellent	L. C 1	10
18	F	U	2	Closed	11	Excellent	R. C 1	11
19	F	B	6	Closed	6	Fair	R. C 2 L. --	12
20	F	U	2	Closed	9	Excellent	L. C 1	9
21	M	U	1½	Closed	6	Execllent	L. C 1	10
22	M	U	3	Closed	9	Good	L. C 1	11
23	F	B	6	Closed	6	Poor	R. AR 2 L. AR 2	10
24	M	B	2	Closed	7	Fair	R. C 1 L. AR 2	10
25	M	U	3½	Closed	6	Fair	L. C 2	10
26	F	U	44	Open	3	Fair	R. AR 2	10
27	M	U	1½	Closed	3	Poor	L. C 2	10
28	F	U	2½	Closed	8	Fair	R. AR 1	11
29	M	U	6	Open	8	Fair	R. C 2	12
30	F	B	1½	Closed	7	Good	R. AR 2 L. C2	11
31	F	U	4	Closed	20	Excellent	L. C 1	12
32	F	U	1½	Closed	6	Good	R. C 1	10
33	F	U	2½	Closed	7	Good	L. C 2	10
34	F	U	9	Open	3	Good	L. C 2	10
35	F	U	1½	Closed	7	Good	R. C 2	12
36	F	U	3	Closed	12	Fair	L. C 2	10

TABLE II.—Concluded

Case number	Sex	Unilateral or bilateral	Age at beginning treatment—yrs.	Method of reduction	Period of immobilization—mos.	Clinical end-result	X-ray classification (Fairbank)	Time under observation—years
37	F	U	1½	Closed	6	Fair	L. --	16
38	M	U	2	Closed	7	Excellent	L. C 1	10
39	F	B	7	Open	5	Poor	R. C 2 L. C 2	10
40	F	B	3	Closed	15	Fair	R. C 2 L. AR 2	18
41	F	U	2	Closed	7	Excellent	L. C 1	12
42	M	U	4	Closed	12	Poor	L. AR 2	10
43	F	U	3½	Closed	16	Poor	R. AR 2	12
44	F	U	1½	Closed	8	Good	R. C 2	14
45	F	B	2½	Closed	13	Good	R. C 2 L. C 2	10
46	M	U	2	Closed	9	Good	L. AR 1	15
47	M	B	2	Closed	11	Excellent	R. C 2 L. C 2	7
48	F	B	4	Closed	11	Poor	R. AR 2 L. AR 2	17

the antetorsion of the femoral neck necessary to secure adequate stability after reduction (Cases 22, 24, 25, 30, and 33). In each case, manual osteoclasis was done just above the femoral condyles and, with the hip held in a position of internal rotation, the distal fragment was rotated outward until the patella faced directly anterior. Manual osteoclasis was performed on 7 femurs in 5 cases and in only 2 hips was the anatomic end-result rated good. This operation may be necessary in the case with marked antetorsion of the femoral neck but derotation takes place as a rule in sufficient degree to result in a stable reduction.

COMPLICATIONS

The complications which arise in the treatment of congenital dislocation of the hip are well known and for that reason, only those that occurred in this series of cases will be mentioned. A complication to treatment may be some pre-existing condition as well as some undesirable aftermath following reduction. Case 3 presented typical findings of osteogenesis imperfecta congenita prior to the onset of treatment for bilateral congenital dislocation of the hip. Multiple fractures occurred during the period of treatment and prevented retention of the hips after reduction. Both femurs were involved: the left was fractured by a fall while the hips were in the second position without the legs being incorporated in plaster, and

Fig. 1, left. Case 9. M. M., female aged 2 years. Roentgenogram made in 1929 shows left hip prior to manipulative reduction.

Fig. 2. Roentgenogram made in 1939 shows normal anatomical structure in left hip. Example of class I cure.

the right sustained a greenstick fracture during a remanipulation of the hip. Incidental fractures during the course of treatment included the left tibia and fibula on 2 occasions, a second fracture of the left femur, and a fracture of both bones of the left forearm.

An acute streptococcus infection of the throat with an elevation of temperature to 106.4 degrees developed in Case 7 during the 6th month of treatment. The use of antistreptococcus serum produced a rapid subsidence of symptoms, and the infection resulted in no ill effect in regard to the reduced hip. This patient had an excellent end-result when examined 11 years after the reduction.

Diphtheritic symptoms developed in Case 9 during the 2d month after reduction, and the child was treated with antidiphtheritic serum. The temperature rapidly declined and the infection produced no undesirable sequelae.

Fig. 3. Case 1. S. B., female, aged 5 years at time of manipulative reduction. X-ray film made in 1939 shows anatomical reduction but marked distortion of femoral heads and necks. Class II cure. (Pre-reductive x-ray made in 1923 of too poor quality to reproduce.)

Pneumonia is not an uncommon postoperative complication in all types of surgery and developed in Case 14 during the 7th month after reduction. This case had a poor anatomical end-result although there was no indication in the case record that the hip was involved secondary to the lung infection.

Nerve injury as a complication to reduction was present in only 1 case. A paralytic foot-drop was an immediate complication following reduction in Case 23, but the patient had made a complete recovery when the final plaster was removed at 6 months.

Redislocation and subluxation are not uncommon occurrences in the course of treatment of the congenital dislocated hip. In the majority of cases, surgical plastic procedures are done, and construction of a shelf over the femoral head is the most frequent plastic operation. Shelving operations were carried out in Cases 13, 19, and 36, at 4, 5, and 10 years after the original reduction respectively.

CLASSIFICATION

The 48 cases reviewed in this series, which have been under observation over a period sufficiently long to evaluate with some degree of accuracy, the end-result of the congenital misplaced hip after treatment, have been classified both from functional and anatomical findings. Fairbank in 1922, attempted to group his late results of congenital dislocation of the hip and devised an x-ray classification which is simple and yet sufficiently complete to allow a reliable estimate of the results obtained. It is this classification upon which the anatomical findings in the present series are recorded.

The first group in the Fairbank classification (class I cures) includes those cases in which the

Fig. 4, left. Case 10. K. M., female, aged 2 years at time of manipulative reduction. X-ray film shows right hip dislocated and left hip subluxated. (1925.)

Fig. 5. X-ray film made in 1936 shows right femoral head to be nearly normal in configuration but riding opposite the upper lip of the acetabulum. Anterior reposition I.

head of the femur is in the acetabulum and approaches the normal in size and shape as disclosed by x-ray (Figs. 1 and 2). It is to be expected that this group of patients has essentially normal clinical findings. Of the 48 cases reviewed, 18 belong in the class I cures and a good or excellent functional result is present in 16. The average age in this group was 3 years at the time of reduction (Table II).

The functional end-result has been rated as excellent when the hip presented practically full range of motion and was painless and stable. A good result includes those hips with some limitation of motion but otherwise painless and fairly stable. A fair end-result is given to the group of hips that became painful after moderate activity or were moderately unstable in walking or both. Limitation of motion was present in most of these cases. The poor end-result group contains all other cases not classified in the preceding groups.

Among the class II cures, are placed those which show an equally definite anatomical cure, but in which the head of the femur is distinctly abnormal, either in the direction of being mushroomed, varoid, or of being partly or completely worn away by absorptive arthritis, a term used by Fairbank (Fig. 3). Nineteen cases were found in this group. The functional end-result was good in 9 and fair in 7. One case rated excellent but was only 7 years after reduction. The 2 remaining cases were poor (Table II).

In the foregoing groups, the femoral head has been replaced and retained in the acetabulum. Unfortunately a considerable number of cases fail to maintain this reduction through some anatomical variation but the femoral head has been changed from a posterior dislocation to an anterior position. The anterior repositions are divided into two groups by Fairbank according to the roentgenological findings. Of course, these groups do not include untreated cases, in which the femur remains in its original position posterior to the acetabulum.

Anterior reposition I, means that the case presents a fairly well formed rounded head opposite the upper lip of the acetabulum with or without the formation of a false acetabulum at this point. Instability is the most prominent symptom in this group although pain may be a major issue (Figs. 4 and 5). In this group, 3 cases have been included by their x-ray findings but the functional end-result was rated good in 2 of them, Cases 10, 28, and 46 (Table II). The other case being classified as fair.

Anterior resposition II, includes all cases with gross changes in the bones, which usually take the form of flattening and absorption of the head of the femur, and flattening and condensation of the bone at the site of the upper lip of the acetabulum (Figs. 6 and 7). This group includes 14 cases and 17 hips of which 4 cases had a functional end-result of good, 6 rated as fair, and 4 were classified as poor (Table II).

CASE REPORTS

The following case reports are of the patients whose roentgenographs were used to illustrate the x-ray classification followed in this group of cases.

Case 9. M. M., female, was aged 2 years when first seen in July, 1928. The family history was negative in regard to congenital abnormalities. Nothing unusual was noticed about the patient until she began to walk and developed a waddling gait.

Examination disclosed a sturdy child who walked with a moderate left limp. No lordosis was noted. The Trendelenburg sign was positive on the left, telescoping of the left thigh was present and the greater trochanter could be palpated in a superoposterior position. Abduction was also limited. Roentgenographs made on July 11, 1928, disclosed the left hip to be dislocated superiorly (Fig. 1).

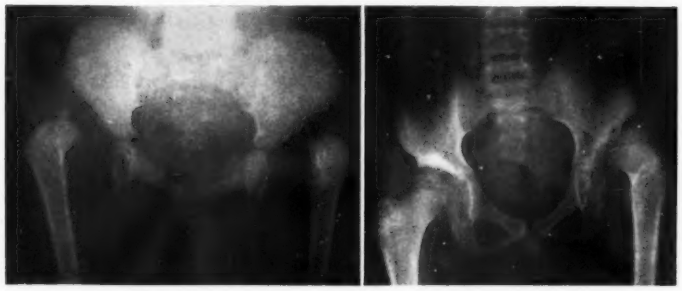

Fig. 6, left. Case 24. S. H., male, aged 2 years at time of manipulative reduction. X-ray film made in 1930 shows bilateral dislocation of the hips.

Fig. 7. X-ray film made in 1940 shows almost normal anatomical result on the right and a distorted femoral head above the superior lip of the acetabulum on the left. Left hip is an example of anterior reposition II.

On July 28, 1928, the left hip was manipulated by the Lorenz method under general anesthesia, and the hip was felt to reduce with a low thud. A bilateral hip spica cast was applied with the hips in a position of 90 degrees of flexion and 90 degrees of abduction. The patient developed symptoms of diphtheria on September 5, 1928, and was treated with antidiphtheritic serum. The original position was maintained until March 1, 1939, when the cast was removed and physical therapy was started. The patient was discharged from the hospital on May 21, 1929 at which time she was walking quite well.

Final examination made on November 15, 1939 disclosed a slight flattening of the left buttock. There was no limp and no measurable shortening. The Trendelenburg was negative and a full range of motion was present in the hip (Fig. 2).

Case 1. S. B., female, was aged 5 years at the time of the first examination on October 11, 1923. Although the parents noted a peculiar gait from the time the child began to walk, nothing was done until the age of 5 years.

Examination on October 3, 1923, disclosed a marked waddling gait. There was a positive Trendelenburg bilaterally, a moderate degree of lordosis, and the trochanters were high. Both hips were free but had some limitation of abduction. The right lower extremity measured one-half inch shorter than the left.

X-ray studies made on the day of examination disclosed a dislocation of both hips, the right being higher than the left.

The patient was placed in traction on October 11, 1923 for a preliminary period. On November 10, 1923 under general anesthesia, both hips were manipulated by the Lorenz method and reduction was accomplished with a distinct thud. The hips were immobilized in the "frog-leg" position and this was maintained until March 29, 1924, when they were placed in a second position. The second cast was removed on July 12, 1924. Due to a flexion contracture in the left hip, the hip was manipulated under anesthesia on August 9, 1924 and immobilized for 2 weeks. The patient was dismissed from the hospital on January 14, 1925 and still had considerable stiffness in the right hip. A marked right limp was also present.

Final examination made on February 2, 1939, when the patient was 21 years of age and working full time in a shop, disclosed practically full range of motion in both hips. There was no shortening nor limp. Both hips were stable (Fig. 3).

Case 10. K. M., female, was aged 2 years when first examined. The family history was essentially negative. The patient began to walk at the age of 17 months, and an obvious limp was noted. She tended to drag the right leg with each step.

Examination on March 11, 1925 disclosed a marked right limp. The right lower extremity measured one-half inch shorter than the left. There was limitation of abduction, and the trochanter was palpated higher than normal.

Roentgenographs made on March 11, 1925 showed the right hip to be dislocated and the left hip to be subluxated (Fig. 4).

The hips were reduced by the Lorenz method on March 28, 1925 and immobilized in the "frog-leg" position until September 12, 1925 when they were placed in the second position of a few degrees, less flexion and abduction. The third position was secured on March 30, 1926 and the cast bivalved on April 9, 1926.

The last examination was recorded on July 28, 1936, when the patient was 21 years of age. She was complaining of some pain in the right knee after walking. The right buttock was slightly flattened but the hip had a full range of motion and was stable. The Trendelenburg was negative but she walked with a slight limp. (There was no measurement noted on the record.) (Fig. 5.)

Case 24. S. H., male, was aged 2 years when seen on March 25, 1930. The family history was essentially negative and the patient appeared to be normal until he began to walk. A right limp was noticed by the parents and medical advice was sought soon afterward.

At the time of examination on March 25, 1930, a pronounced right dip was noted while walking. There was three-quarters inch shortening of the right lower extremity. Both trochanters were apparently high.

Roentgenograms made on the day of examination disclosed a dislocation of both hips (Fig. 6).

On March 27, 1930, under general anesthesia, both hips were manipulated by the Lorenz method but marked instability was found. The hips were immobilized in extreme abduction. The plasters were changed on May 1, 1930 and on May 15, 1930, and the hips placed in internal rotation, abduction, and extension. A bilateral manual osteoclasis in the supracondylar region of femur was done on July 10, 1930. The plaster was removed about 3 months later.

Final examination on April 16, 1940, 10 years after reduction, disclosed a well developed male who walked with a left limp. Although he was able to engage in all types of

activities, he complained of some pain in the left hip at times. The Trendelenburg was positive bilaterally and telescoping was present in the left hip. There was slight limitation of internal rotation and abduction on the left and one inch of shortening. The right hip had full range of motion (Fig. 7).

The technique of Lorenz for reduction of congenital dislocation of the hip has been followed in practically all cases in this series. Although there probably has been some slight modification to suit the individual surgeon, the majority of cases were immobilized following reduction according to the original outline of procedure. The degree of abduction and flexion was at right angles to both planes of the body in almost every instance but the period of immobilization in this position and the other attitudes of less abduction and flexion were entirely dependent upon the stability of the involved hip.

The average period of immobilization in the first or "frog-leg" position was approximately 4 months for all hips treated by the closed method. As this period was of the same duration in the Class I cures as for the other classes, each case was studied for an explanation of the inferior end-results.

Closed reduction which was done after the age of 5 years resulted in unsatisfactory end-results in all cases in this series (Cases 1, 11, 15, 19, and 20). Reduction of the hip was accomplished with difficulty in Case 15, and the hips were not reduced clinically but appeared to be reduced by x-ray in Case 23. The age limit for manipulative reduction is rather low in the opinion of many orthopedists, that is, under the age of 3 or 4 years (Dickson, Fairbank, Putti, Sudbrack, and others), but this procedure is attempted up to the age of 7 or 8 years in numerous clinics. From the undesirable results in the above group of cases, it would appear that the advocates for early reduction have a convincing argument for their opinions. Whether trauma in Case 15 or misleading roentgenograms in Case 23 were responsible for imperfect end-results cannot be definitely determined.

Study of the second group of cases whose end-results left much to be desired disclosed a shorter period of immobilization than the average, but otherwise presented no problem during the course of treatment (Cases 24, 25, 27, 30, and 33). The total period of immobilization averaged 6 months for each case in this group. The presence of very shallow acetabula in Case 24 and sufficient antetorsion to require osteoclasis in Cases 30 and 33 may also be contributing factors in these 3 cases.

Incomplete reduction or failure to maintain reduction in plaster was noted in 3 cases (Cases 4, 23, and 28). Each case required remanipulation 2 to 7 months after the original reduction. Shallow acetabula were present in each case, and probably the same result would have occurred had a second manipulation not been necessary. Marked instability of the hip due to shallowness of the acetabulum usually requires some plastic operative procedure to correct this condition.

Osteochondritis of the femoral head was noted on the records of Cases 35 and 36 as an explanation of the imperfect results in these patients. No undue force was required at the time of reduction, and the convalescence was uneventful in each case. As to whether osteochondritis is secondary to trauma is a matter of opinion and, although it seems to have a smaller incidence in cases requiring less force in reduction, the condition does occur even though no injury has been inflicted. It has been observed to occur in the apparently normal hip in a case of unilateral misplacement (Oberzimmer, 1933).

Except for 6 cases which offer no reasonable explanation for an undesirable end-result after careful study of the records and roentgenographs (Cases 10, 40, 42, 44, 45, and 47), the remaining cases presented individual problems. Osteogenesis imperfecta congenita was present in Case 3. Multiple fractures prohibited retention of the hips after reduction. In Case 14 pneumonia developed with probable secondary involvement of the congenital hip. In Case 43 there were multiple congenital deformities. The dislocated hip was present in a congenital short extremity. Spina bifida and clubfoot were also present. Postoperative infection developed in Case 48 after a shelving operation for the unstable hip and resulted in gross distorsion and redislocation of the femur. Shallow acetabula without operative correction were recorded in Cases 16 and 46 and account for the redislocation in these cases.

CONCLUSIONS

Although this series of 48 cases which have been under observation from 7 to 18 years after reduction is rather small to form definite conclusions, it is evident after study of Table II that the group of cases in which patients were treated by closed reduction under the age of 5 years presented late results both clinically and anatomically far superior to those in the older age groups. Also, a period of postreductive immobilization extending over 10 months produced more class I cures in this age group than when a shorter period of plaster fixation was used. Numerous complications have been presented, each of which appears to have a definite bearing upon the final result.

In a few cases the clinical result was surprisingly superior to the anatomical findings, but as a rule, the more nearly normal the joint appeared, the better was the clinical result.

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THE SURGICAL TREATMENT OF BRONCHIECTASIS

A Report on 76 Patients

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MANY excellent papers have been published in recent years on the subject of the surgical treatment of bronchiectasis and considerable data have accumulated. The immediate mortality has been steadily lowered and the indications for operation are being broadened constantly. Many of the details of operation have been emphasized by Churchill (4), Edwards, Haight, Blades (1), and others. The normal and abnormal surgical anatomy concerned with the operation has been portrayed by Churchill and Belsey (5), Kent and Blades (9, 10), so that it can be said that the operation has become more or less standardized. It is apparent that in the presence of conventional anatomy, lobectomy for unilobar bronchiectasis is a relatively simple operation and carries with it a mortality of not more than 1 or 2 per cent. However, with a more careful iodized oil study of the bronchial system, it is evident that simple unilobar bronchiectasis is not usually encountered. Indeed it seems more likely that many, if not most cases of unilobar bronchiectasis have resulted from the presence of a foreign body or some other form of partial or complete bronchial obstruction. A careful review of the case histories of many patients with unilobar bronchiectasis tends to support such a belief.

More and more patients with bilateral disease are being subjected to bilateral lobectomy with considerable success (Eloesser, Lewis, Overholt, Bradshaw and Chodoff, Blades and Graham). Several patients have had three and a part of a fourth lobe removed successfully. The operative mortality in this group of patients is, of course, much higher than in the unilobar group. It is difficult to obtain exact figures, but the mortality is in the neighborhood of 15 per cent. The mortality in untreated bronchiectasis is about 35 per cent in patients that have been studied to date (Perry and King, Bradshaw, Putney and Clerf). However, it is probable that many more of these patients will die from bronchiectasis or its complications if they are observed for a longer period of time.

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In a discussion of the mortality of operation for bronchiectasis, it seems desirable to include only those patients with no known cause for their bronchiectasis. As a rule in most reports, all operations for bronchiectasis have been grouped together regardless of the probable underlying cause. The changes produced in the thorax as a result of pulmonary abscesses or as a result of a more or less complete bronchial obstruction from tuberculous infection may be very different from those produced by the usual type of bronchiectasis. The amount of dissection required in bronchiectasis resulting from abscesses and the lack of healing often exhibited after the removal of a lobe in the presence of tuberculous involvement, may and frequently does increase the mortality of operation. An attempt has been made in the present report to include only the operations on patients with bronchiectasis resulting from no known etiological agent or agents.

The complication which most often leads to a fatality after lobectomy is infection. Since the operation is usually done as an elective procedure, time should be utilized in getting these patients in the best possible physical condition by means of postural drainage, or repeated bronchoscopies or both, the removal of all accessible areas of infection such as in the paranasal sinuses and teeth, a high vitamin and high caloric intake, and blood transfusions. The use of a sulfonamide before operation has certain advantages as well as some disadvantages. These are well known and need no elaboration here. In this series of cases, some patients have been given a sulfonamide and others have not. There certainly has been no striking difference in recovery in either group. Perhaps more experience will lend evidence one way or the other. If obvious acute respiratory infection is present either in the patient or in the individuals with whom he will come in contact during his hospital stay, the operation should be postponed. The operation should be postponed for at least 6 weeks following the injection of iodized oil.

In the majority of patients in this series, the operation has been carried out under endotracheal oxygen-ether anesthesia. The usual procedure is to give a small dose, ½ grain, of sodium pheno-

barbital the night before operation. The following day, 2 hours before operating time, 1½ grains of nembutal is given and 1 hour before operation, if needed, 1½ grains of nembutal, 1/150 grain of scopolamine, and 1/6 grain of morphine are given. (Cyclopropane and oxygen are used for induction and for the introduction of the endotracheal tube.) Ether is gradually added as the cyclopropane is withdrawn. When the proper level of oxygen-ether anesthesia is reached, the tracheobronchial system is thoroughly aspirated by passing a small catheter through the endotracheal tube. The tube is allowed to project about 1 inch above the level of the lips and a face mask is fitted snugly over all. The oxygen-ether anesthesia is continued throughout the operation. Aspiration can be easily repeated at any time during the operation and should be thoroughly done at the close of the operation before the tube has been removed. If this is properly done, it obviates the necessity for bronchoscopic or other aspiration, at least for a few hours. A few lobectomies and pneumonectomies have been done under continuous spinal anesthesia because of the obvious advantage it presents in allowing the use of a coagulating electrode. Chest wall bleeding in the presence of many adhesions is difficult to control by ordinary ligature or suture-ligature methods. A cautery affords the best means for control, but it is of course dangerous in the presence of an explosive anesthetic mixture. The patients under continuous spinal anesthesia have not been entirely comfortable unless rather large doses of morphine and scopolamine are given at intervals throughout the operative procedure. The cough reflex may be active despite the infiltration of hilar structures with 1 per cent novocain solution. This is troublesome when the pulmonary vessels are being ligated and the bronchus is being sutured. It would be highly desirable if this or some other method were developed which permits the safe use of a cautery inside the thorax.

It is ideal if at all possible, to ligate individually the vessels and the bronchus of the hilum of the lobe. This permits the removal of a greater length of the bronchus. The older method of mass ligation of the hilum was not a clean-cut procedure and left a mass of tissue to become necrotic and slough into the pleural cavity. This undoubtedly contributed to, if it did not actually cause, many of the extensive postoperative empyemas. Unfortunately, it is not always possible to do individual ligations because of extensive disease which causes such a dense matting together of the vessels and bronchus that their dissection would be hazardous. Enlarged, adherent lymph nodes may make it impossible to bare the structures for individual ligation. Under such circumstances, it is often possible to ligate the inferior pulmonary vein to the lobe, divide it, and then apply a lobe tourniquet. This manipulation aids considerably in the production of a small stump. It should be emphasized that it is unwise to persist in attempts at individual ligations in the face of a disease process which makes separation of the structure unlikely or impossible. The hilum should be properly exposed and the possibility of individual ligation quickly determined before a long tedious dissection is undertaken that may have to be abandoned in favor of mass ligation.

If the fissures between lobes were always complete and if the structures of the hilum were always easily separable, pulmonary lobectomy would be a relatively simple operation; unfortunately that is rarely the case. It is sometimes possible by temporarily occluding a lobe bronchus and slightly overinflating the surrounding lobes to find a line of demarcation which can be carefully dissected and not produce bleeding from either lobe. This is not often possible if the fissure has not been present at one time. Frequently, the vascular and bronchial systems between parts of lobes communicate freely with each other. Many clamps have been devised for controlling hemorrhage during the separation of the lobes, but none has proved to be satisfactory. It is fairly efficient to start two running lock-stitch sutures of a fine chromicized gut to control the hemorrhage as the formation of the fissure begins. If the sutures keep pace with the dissection, very little blood is lost. Mattress sutures of fine silk can be used to bring pleural surfaces together over the raw area of the lobes. During the last 3 years, after the lobe has been removed and all bleeding controlled, sulfanilamide has been dusted on the hilar region. Formerly, intercostal tube drainage was used in all patients for a number of days. It became evident that shorter periods of drainage were adequate in patients that had little sputum, had not had bouts of pneumonitis, and had had a clean cut removal of the lobe with a very small stump remaining and no obvious soiling of the pleura. Under these conditions the tube remained in place until the pneumothorax has been removed, the lung re-expanded and the drainage was small in amount and contained a few or no organisms. Frequently the tube was removed within 48 hours. With the advent of sulfanilamide apparently an occasional patient will need no drainage at all. It is likely that some of this latter group of patients will need drainage of a residual empyema. Certainly the period of hospitalization is shortened

by weeks if no drainage is required. A report on all patients that have been closed without drainage should be made from time to time to determine whether or not such a plan is desirable in the majority of patients. The economic loss to hospitals by the prolonged stay of patients who have been drained is considerable, and anything which will safely allow the earlier discharge of them should be encouraged.

In a discussion of the mortality from operations for bronchiectasis it is essential to know just the type and extent of the disease under discussion. As has been indicated, so called primary bronchiectasis carries with it a considerably lower mortality than does bronchiectasis secondary to abscesses and tuberculous infections. Furthermore, the extent of the disease influences the outcome. In a report on this disease, therefore, it is desirable to indicate clearly the nature and extent of the disease rather than to discuss, without qualifying it, the mortality following lobectomy for bronchiectasis. The feasibility of the operation has been unquestionably established. During the early stages of development of the operation, it was necessary to be extremely careful in the selection of cases to prevent its falling into disrepute. But with the high mortality which is known to occur in untreated patients and with the chronic invalidism present in those that do not die, it is logical to extend indications for operations to the fullest extent. This is being done in many clinics. The philosophy of the operating surgeon is a most important factor. The general policy of the authors has been to refuse to operate only on elderly patients with bilateral disease.

The results in 76 patients operated upon for primary bronchiectasis, in so far as the clinical history and findings permitted such a diagnosis to be made, are as follows:

1. Twenty-four patients with lower lobe or lower lobe and lingula disease were operated upon with 1 death, a mortality of 4.2 per cent. All obviously diseased lung tissue was removed.

2. Twenty-six patients had one lobe removed but disease was present in other lobes with 4 deaths, a mortality rate of 15.4 per cent.

3. Seventeen patients had 2 or more lobes removed with 3 deaths, a mortality of 18 per cent. Eleven had disease in other lobes.

4. Pneumonectomy was performed on 9 patients with 4 deaths, a mortality of 44 per cent. Disease was present in the remaining lung in all the patients who died.

From these results certain facts seem clear. With minimal disease that can be completely removed, the results are excellent. One death that occurred in this group was due to an error in judgment. In this patient, attempts at dissection lobectomy should have been abandoned and resort had to the cautery. If disease is present in many lobes, the most diseased lobe can be removed with relative safety but the mortality is probably 3 to 4 times as great as it is in single lobe and lingula disease. Multiple lobes can be removed in the presence of disease in remaining lobes with only a slightly greater mortality than occurred in single lobe removals in the presence of disease in some of the remaining lobes. Pneumonectomy can be safely done if the disease is limited to the side that is removed. Although the present series of pneumonectomies is not great enough to be significant, the results when disease is present in the controlateral lung, do not seem to justify the procedure.

The extent and type of bronchiectasis play an important part in the difficulty of operation and the subsequent mortality. Certainly minimal cylindrical changes in a lobe are not as serious as large saccular dilatations. In these 76 patients, when a lobe has been called "diseased" it means that there is definite evidence of bronchiectasis by iodized oil studies. Those lobes whose bronchi appear to be only "top normal" in size are not considered in this analysis.

The causes of death in the 12 patients that died are as follows: (1) Four patients had flooding of the remaining bronchi with pus despite frequent bronchoscopies or continuous endobronchial suction drainage. One 5 year old boy also had a 60 gram thymus. (2) Two had bilateral pneumonia or pneumonitis. (3) Cerebral abscesses developed in 2 patients. (4) Thyroid and hepatic abscesses were present. (5) Septicemia, pericarditis, and perforated duodenal ulcer were present. (6) Abscesses were noted in opposite lung. (7) Hemorrhage from inferior pulmonary vein.

SUMMARY AND CONCLUSIONS

1. An analysis has been made of the results in 76 patients who have been operated upon for so called primary bronchiectasis. These patients represent an attempt to care for the routine admissions to the hospital and were not selected with the view of establishing any kind of record.

2. The mortality in patients with untreated bronchiectasis is 35 per cent to date.

3. The mortality in patients that have been operated upon for minimal bronchiectasis is 4 per cent or less.

4. The mortality in patients who have been operated upon for extensive bilateral disease is 44 per cent.

5. The technical difficulties of pulmonary lobectomy are emphasized.

6. The causes of death in patients who have been operated upon for bronchiectasis are tabulated.

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OMPHALOCELE

Anatomical and Clinical Considerations

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OMPHALOCELE is a rare condition in which various abdominal viscera are found at birth in the base of the umbilical cord. Omphalocele may be differentiated from ordinary umbilical hernia by the observation that the covering of the former consists of two avascular fused membranes, amnion and peritoneum, whereas the covering of the latter consists of skin.

As pointed out by Clagett and Dixon, there has been considerable confusion in the literature regarding the name of this anomaly. Omphalocele, eventration, congenital umbilical hernia, hernia into the umbilical cord, amniotic hernia, funicular hernia of the umbilicus, and exomphalos have been used synonymously. The authors prefer the term omphalocele which term is sufficiently descriptive to differentiate the condition from postnatal umbilical hernia.

INCIDENCE

Since the report of the first case in 1634 about 400 cases have been recorded, nearly half of these since 1900. The incidence has been variously estimated, the usual figures being 1 to every 5,000 or 6,000 infants. This incidence implies that many cases have occurred which have not been reported.

Less severe forms in which only portions of the intestinal tract are included in the sac are twice as common as those in which the liver, gall bladder, and spleen are also present. There seems to be a predilection for the male sex, only half as many being present in females.

EMBRYOLOGY

In order to understand the mechanism of the production of omphalocele a brief review of the embryology of the digestive tract is in order.

Up to 4 weeks of development, the digestive tract resembles a straight tube. Attached to it ventrally is the yolk stalk or vitelline duct which extends through the umbilical aperture into the umbilical cord. The gut tract, below that portion destined to be stomach, possesses no ventral mesentery but is attached only to the dorsal body wall by the dorsal mesentery. The superior mesenteric artery runs through the dorsal mesentery to supply the gut in the vicinity of the yolk stalk.

Beginning with the second month, the relative rate of growth of the intestine and liver is more rapid than that of the tissues bounding the celomic cavity. To relieve the resultant crowding of the viscera there develops a ventral extension of the peritoneal cavity into the base of the umbilical cord. This space is normally occupied by those portions of the intestine which are adjacent to the site of attachment of the yolk stalk and which are supplied by the superior mesenteric artery. There is thus formed a so called physiological umbilical hernia.

When the gut first herniates into the base of the umbilical cord, it consists of a single loop with the yolk stalk attached at the bend of the loop, the loop being in the sagittal plane. Rotation of the gut begins soon after the establishment of the hernia. According to Dott's classical description, the rotation of the gut occurs in three stages.

First stage. The first stage of rotation takes place between the 5th and 10th weeks of intrauterine life. It consists of a counterclockwise rotation (when the specimen is viewed from in front) of the loop of gut which occupies the umbilical hernia with the superior mesenteric artery serving as the axis of rotation. The rotation continues through more than 180 degrees or until the cephalic limb of the loop lies beneath and to the fetus' left of the caudal limb. It is during this stage that atrophy of the yolk stalk normally occurs.

Second stage. At the onset of the second stage the development of the abdominal cavity has overtaken that of the viscera, and the intestinal tract is withdrawn into the abdomen. For reasons that are not positively understood, the cephalic portion of the loop is withdrawn first. As this cephalic portion is withdrawn from the hernial sac, it lies behind the superior mesenteric artery and occupies the central portion of the general peritoneal cavity. This crowds the unherniated portion of the colon to the left. The return of the caudal portion of the herniated gut to the general peritoneal cavity constitutes the final phase of the second stage of rotation and occurs at about the 11th week.

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There is a lack of general agreement as to the factors which cause the reduction of the physiological umbilical hernia. It is conceded that one or more of the following factors may be responsible: (1) a negative intra-abdominal pressure produced by a relative retardation in the rate of growth of the liver; (2) positive extra-abdominal pressure; (3) traction exerted by the mesentery because of a relative retardation in its rate of growth; (4) tension exerted by the nonherniated portions of the gut. (Mall, after studying pig embryos, suggested that an increase in the number of intra-abdominal loops of the intestine and their rotation may draw upon the herniated portion.); (5) pressure exerted against the inferior portion of the hernia because of enlargement of the umbilical arteries.

In the normal course of events the return of the intestine to the abdominal cavity is promptly followed by an obliteration of the sac of the umbilical hernia.

Third stage. This stage is characterized by the descent of the cecum into the right lower abdominal quadrant and the fixation of the duodenum and portions of the colon to the posterior abdominal wall. This stage extends from the 11th week until birth or shortly after.

Anomalies in rotation may take place in any one of the three stages. Most commonly they occur in either the second or third stage. According to Dott, anomalies in rotation are 3 times more common in males than in females.

ETIOLOGY

Many suggestions have been made as to the cause of omphalocele. This much is certain that anything which hinders or prevents the normal return of the intestine to the abdominal cavity must be considered a possible cause. Milch, quoting various authors, suggested the following factors: persistence of the fetal concavity of the dorsal spine, arrest in the development of the primitive vertebrae and the abdominal walls, persistence of the yolk stalk, and the presence of fetal peritonitis. The most commonly accepted explanation is that there exists a disproportion between the abdominal viscera and the abdominal cavity. This disproportion usually results from a retarded development of the abdominal parietes. This factor may become active during the second stage of rotation of the gut or it may develop later so that the liver or other organs herniate through an umbilical aperture that has not been obliterated.

Although most of the cases can thus be interpreted, there are still some that defy explanation. Among these are some in which most of the anterior abdominal wall consists of a transparent membrane. Thunig speaks of this condition as amniotic linea alba.

REPORT OF CASES[1]

CASE 1. The mother of this infant was a 30 year old multipara who had borne 2 previous children, both of which were living and well. She had been in good health except for a chronic eye complaint and for a Trichomonas vaginalis infection the previous year. The latter readily cleared up under treatment. No complication of pregnancy was noted aside from ankle edema. The infant (male) was born at home spontaneously at term following a normal labor. Cry was immediate and vigorous. Except for the omphalocele, the infant was in good health. Taxis failed to reduce the hernial mass. In fact it grew larger with each cry. Upon hospitalization the protruding mass appeared as in Figure 1.

When the sac was opened at surgery it was found to contain approximately the lower half of the ileum, the cecum and at least a portion of the ascending colon. A Meckel's diverticulum was noted. After the intestine was freed from the sac and returned to the abdomen, the cord was doubly ligated. The peritoneum was closed and the rectus muscles were approximated with chromic catgut suture. After bringing together the subcutaneous tissue with plain catgut, the skin was sutured with silk.

The surgery was completed under local anesthesia within 6½ hours following birth. The infant was discharged from the hospital on the 10th day after an uneventful postoperative course.

At the time of writing, the child is more than 2½ years of age and there is no apparent weakness in the anterior abdominal wall (Fig. 2). Recent roentgenographic examination of the intestinal tract has shown no malposition of the intestinal tract. Neither could a Meckel's diverticulum be demonstrated.

CASE 2. The mother in Case 2 was a 33 year old Japanese multipara (secundipara, trigravida) who gave a history of having had tuberculosis 3½ years previously (arrested). The infant (female) was delivered in good condition except for a large omphalocele. Several lactogen feedings were given prior to operation. Surgery was done under ether anesthesia 59 hours after delivery. The hernial sac showed some evidences of necrosis by the time of operation. The sac contained the liver, spleen, stomach, and intestine. The abdomen was poorly developed and obviously inadequate to accommodate the usual structures. Partial reduction of the mass was accomplished by taxis and opening of the sac. The liver was firmly adherent to the entire superior portion. The mesentery was poorly developed. After the viscera were freed and placed in the abdominal cavity it was found that the muscles could not be approximated. Closure was accomplished by suturing together the skin margins, with the use of interrupted silk as described by Ladd.

The prognosis immediately after operation was considered to be poor. For the first week after operation the infant was given lactated Ringer's solution subcutaneously several times daily and frequent carbogen inhalations. Three small stools were passed on the day of surgery. Feedings by mouth began the 2nd postoperative day. After 6 days the temperature remained normal and the infant was discharged in 3 weeks in good condition.

CASE 3. A white male infant was delivered spontaneously at term from a 25 year old multipara (trigravida, pri

[1]Drs. James W. Burton, Floyd E. Neff, J. Norton Nichols, and Thomas I. Zirkle were most helpful in making available cases and case records, and Dr. Loleta E. Simpson for her roentgenographic studies.

Fig. 1. Photograph of infant in Case 1, before operation, showing the relation of the omphalocele to the umbilical cord and to the body wall.

mipara, one abortion). Some difficulty was encountered in delivering the abdomen because of the large omphalocele. The cry was spontaneous but weak. The omphalocele consisted of a mass (10 by 10 by 5 cm.) enveloped by a transparent membrane. The orifice connecting the sac with the abdominal cavity was about 5 centimeters in diameter. The cord was attached 4 centimeters from the skin margin. The infant also presented cryptorchidism.

In spite of the large sac, surgery was begun 7¾ hours after delivery under open drop ether anesthesia. Oxygen was given throughout the operation. It was found that the liver, spleen, and intestine were contained in the sac. The liver was firmly adherent to the anterior portion of the sac. The midgut had not rotated and the abdominal cavity was not well developed. Since the hernial contents could be only partially reduced by compression, the neck of the sac was split upward and downward through the abdominal wall. Finally, when the hernial contents had been reduced as far as possible, the liver occupied the entire right side of the abdomen, and the intestine and spleen the left side. The abdominal wall was closed with interrupted heavy black silk sutures for the most part bringing only the skin together. In spite of the administration of continuous oxygen and several stimulants the infant expired 10 hours after surgery.

Case 4. This infant was delivered at 8 lunar months from a primigravida. Both parents were in good health. The mother's prenatal course was uneventful except for a troublesome vaginal discharge, the cause of which could not be determined. After a somewhat lengthened labor, birth was spontaneous. No difficulty was encountered in delivering the infant's abdomen. At birth the fetal heart was still heard. The baby gasped several times but lived only a few minutes.

Practically the entire anterior abdominal wall was absent (Fig. 3). A large mass 7 by 6 by 6 centimeters protruded forward beyond the usual location of the abdominal wall. A translucent membrane covered the mass and was attached to the skin, on either side, at the lateral abdominal wall; above, to the skin at the lower rib margins; and, below, to the skin over the symphysis pubis. The membrane forming the sac was very much thickened and opaque in its lower third and was thrown into numerous large and small folds. The hernial mass contained the entire liver, gall bladder, spleen, stomach, and the intestine. The liver occupied the left upper portion of the mass. Its superior surface was adherent to the covering membrane. The umbilical vein entered the lower aspect of the liver. The duodenum was not retroperitoneal but possessed a mesentery and was freely movable. No ileocecal junction or vermiform appendix could be identified. The intestine was collapsed and could be followed through its many coils until it opened externally through that part of the thick membrane which covered the lower portion of the hernial mass. About 2 centimeters below this opening there appeared a second opening into a blind sac which measured 1 centimeter in diameter. The area of the covering membrane between these two openings was thrown into numerous folds or trabeculae. Histological study of this membrane showed its structure to be that of large intestine. The position of the intestinal tract was typical of nonrotation. The kidneys were in normal position. The ureters were dilated and terminated in the covering of the hernial sac below the site of the intestinal orifices. Sections taken from the region of the urethral orifices showed transitional epithelium. This was the only clue as to the presence or absence of a urinary bladder. The abdominal cavity was almost entirely occupied by the vertebral column. The

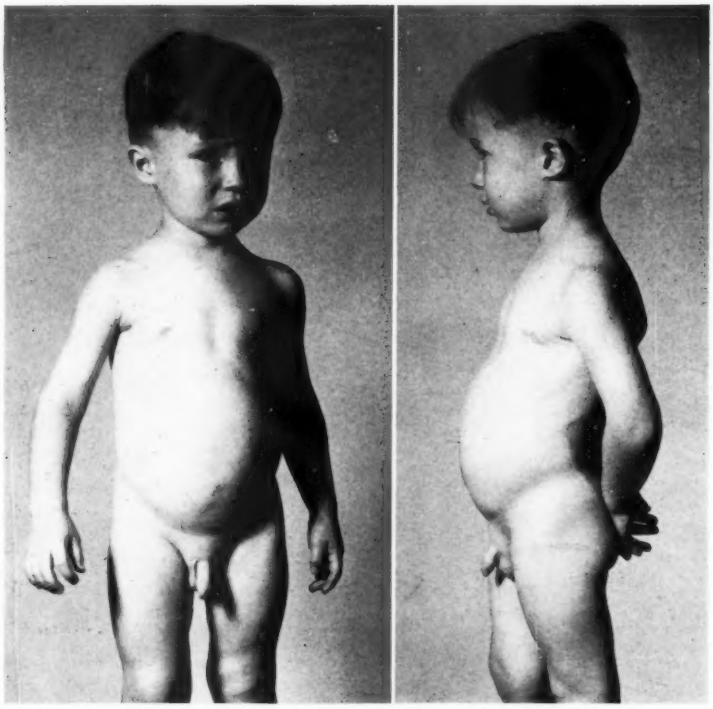

Fig. 2. Photograph of child in Case 1, at the age of 2½ years.

innominate bones instead of being fused anteriorly were widely separated. The following additional anomalies were also noted: undifferentiated external genitalia, bilateral cryptorchidism, infantile type of coarctation of the aorta, a single umbilical artery, spina bifida occulta, webbing of the 2d and 3d toes on each foot, and right clubfoot.

CASE 5. The mother in this case was a 17 year old white primipara who was in good health. Her prenatal course was normal and uneventful except for frequent vomiting during the first 4 months. After 19 hours of labor she spontaneously delivered an 8½ lunar month stillborn premature female. Never were the fetal heart tones heard during labor.

The infant (Fig. 4) weighed 3 pounds and 3 ounces and measured 42 centimeters in length. The most obvious deformity was the large mass of organs lying on the anterior abdominal wall, even extending up over the chest. The mass was 12 by 9 centimeters in size and consisted of liver, spleen, stomach, and both large and small intestines. This mass had no covering nor could the remnants of one be found. These organs were connected with those inside the abdomen through an opening 3.5 by 3 centimeters in the center of the anterior abdominal wall. The liver occupied the right upper portion of the mass and the spleen the left. The large intestine was entirely on the left side with the small intestine above and between the liver and colon. The entire liver was outside of the abdomen. The gall bladder was found within the liver substance. Most of the small intestine seemed distended, the proximal portion being soft but the distal, rather firm. The ileocecal junction and appendix were found in the left lower portion of the mass of herniated organs. At two different locations in the colon there was narrowing of the lumen but obstruction was not complete. The superior mesenteric artery had no direct relation to the duodenum. Rotation was apparently normal up to the point of withdrawal from the cord.

Other anomalies encountered were cranium bifidum, congenital amputation of the fingers of the left hand, webbing between the 3d and 4th toes of the left foot, and a right clubbed foot.

EVALUATION

The present series of cases illustrates the possible variation in the severity of omphalocele ranging as it does from that in Case 1 which presented a relatively simple herniation of a portion of the intestine to that in Case 5 in which the major abdominal viscera were outside the peritoneal cavity and were not even covered by a membranous sac. Fortunately the commonest cases are the least severe. They consist typically of a transparent or translucent sac in which is found a loop of the intestine. Rarely are other organs present without the intestine. As pointed

out by Ladd and Gross, the size of the sac bears no direct relation to the size of the defect in the abdominal wall. The skin usually stops at the base of the sac or continues onto it for only a short distance.

Most authors emphasize the character of the sac. At delivery it is soft and pliable, but because of its poor blood supply it soon becomes opaque, dry, friable, and even necrotic. Jarcho collected 27 cases in which the sac was completely absent, torn, or consisted of remnants. Krumm mentioned a case in which the sac was completely absent as in Case 5 of the present series. Although the sac may rupture under the stress of labor, Jarcho noted that an omphalocele rarely causes difficulty at the time of delivery because the mass is soft and somewhat movable. One of the two patients operated upon by O'Leary and Clymer survived a tear in the membrane bounding the omphalocele. Klopp reported a case in which hemorrhage took place from torn umbilical vessels.

Usually the diagnosis of omphalocele is obvious and immediately recognized by the obstetrician. A warning should nevertheless be given regarding those very mild cases in which only a small loop of intestine is present in the cord. Clamping and ligating the intestine with the cord will, of course, produce intestinal obstruction. Even though recognized soon after ligation a fistula will result.

Practically all authors stress the frequency of associated anomalies. In the 5 cases described herein, all but 1 were known to have presented other anomalies. Although the incidence of persistent yolk stalk is higher in cases with omphalocele than in the general run of cases, it cannot be assumed that the persistent yolk stalk is necessarily responsible for the development of the omphalocele. In this connection it is interesting to note that the case reported by Niebuhr, Dresch, and Logan presented an omphalocele which contained no portion of the intestine.

Infants with omphalocele present no symptoms until several hours after delivery. Inasmuch as the umbilical aperture is usually large, obstruction or strangulation seldom occurs. Symptoms, when they do appear, depend upon the development of necrosis of the sac of the omphalocele, infection, or actual peritonitis. Early surgical treatment is imperative.

It is possible that there has been an overemphasis of the etiological significance of concavity of the fetal spine which has been observed in some cases of omphalocele. In the present series, the infant in Case 4 was the only one in which the deformed vertebral column might have contributed to the development of the omphalocele.

Fig. 3. Photograph of infant in Case 4, showing the extensive defect in the anterior abdominal wall.

Searle and Ingmire have called attention to the possibility that a disproportion of the maternal pelvis may increase the curvature of the fetal back, thus preventing extension of the abdominal cavity so as to leave no space for the abdominal organs. If such a factor were active in every case of omphalocele, it would seem that there should be repeated instances of omphaloceles occurring in the children of one family. Most authors agree, however, that there is no familial tendency.

Along with an omphalocele, the infant in Case 4 presented what Dott described as extroversion of the cloaca. "In this condition the ureters, genital ducts, and intestinal canal all open on the extroverted area. The ileum usually opens on the surface, and the large intestine is represented only by histological remnants on the extroverted area. A very short intra-abdominal portion of the large bowel may be present."

TREATMENT

Inasmuch as in untreated cases of omphalocele the covering sac soon becomes desiccated and peritonitis ensues, prompt treatment is imperative. Jarcho, in his summary of the various methods of treating omphalocele, concludes that

Fig. 4. Photograph of infant in Case 5, showing ectopic viscera, cranium bifidum, amputation of fingers of the left hand, and clubbed foot.

conservative treatment is justified only when surgical facilities are not available. Although a few cases have survived such conservative treatment as adhesive plaster or alcohol compresses, in the average case, surgery provides the only rational method of treatment. It is advisable to operate within 6 hours of birth for the reason that at this time the intestinal contents are, as yet, sterile and negligible in quantity. No feeding should be permitted prior to surgery.

The precise technique of operation will vary with the findings in each case; no fast rules can be laid down. Ladd and Gross state that replacement of the viscera, excision of the sac, and closure of the abdominal wall are the essential features. It is admitted that replacement may be difficult in a poorly developed abdomen.

At operation, each umbilical vessel must be carefully ligated as it is encountered. Healing is more prompt and the scar stronger if the edges of the sac are freshened before closure. Precaution must be taken, however, lest so much skin be cut away that there is insufficient to cover the wound. A safe procedure is to leave the trimming of the skin until the excess can be determined at closure. After the layers of muscle and fascia are freed as much as possible, the peritoneum and posterior rectus sheath should be closed by continuous suture. The recti can then be sutured together in the midline, the anterior rectus sheath approximated, and the skin closed.

In many cases (as in Cases 2 and 3 of the present series) the closing of the abdomen is the most difficult part of the surgical procedure. In some cases the wound can be closed by layers while in others this is impossible and it becomes necessary to use heavy, interrupted, through-and-through silk sutures. In still other cases only the skin can be approximated. Secondary repair of the wall after it has stretched may be necessary when the wound cannot be closed by layers. O'Leary and Clymer mention that the extraperitoneal method of closure is preferable but admit that it is often impractical.

Something should be said of the method of handling the adhesions which are commonly found between the sac and its contents. Adhesions between the intestine and the sac can usually be readily separated. This is not true, however, of adhesions between the liver and the sac. Regardless of the care taken, troublesome bleeding may result after adhesions are stripped from the liver. If the liver is so adherent that hemorrhage seems inevitable, the procedure of choice is to replace

the liver with the sac attached and close the abdomen as usual. Placing a superficial structure inside the abdomen may sound unconventional but such cases, without resulting peritonitis, have been reported by Stanton and by Searle and Ingmire.

Closure of the abdominal wall should be attempted at all odds. Successful repairs have been accomplished even in those cases in which the sac of the omphalocele had been torn. The authors find no case reported, however, in which there has been an attempt to close the abdomen when the sac of the omphalocele was entirely absent.

Dott, in his report of 2 cases, emphasized the necessity of replacing the viscera, particularly the bowel, in as normal an anatomical position as possible. Since the gut is usually very poorly fixed in cases of omphalocele, volvulus may occur subsequently when proper fixation is not provided at surgery.

It is pointed out by Ladd and Gross that although newborn infants usually tolerate the shock of anesthesia and surgery, there are 3 complications that may arise: first, respiratory embarrassment and cyanosis may result from the upward pressure of the diaphragm; second, abdominal pressure against the inferior vena cava may produce circulatory collapse; and, third, excessive pressure against the intestine may cause temporary or partial obstruction. If the infant survives the 48 hours following operation, the chances for recovery are excellent.

According to O'Leary and Clymes the prognosis in omphalocele depends upon the diameter of the abdominal defect, the size of the hernial mass, and the time elapsing before intervention. To this list should be added the particular viscera that happen to be contained within the sac.

Of 20 cases reported by Gross and Blodgett, 10 survived. Most of those lost were in the early part of the series when an attempt was always made to close the fascia. O'Leary and Clymes, in their review of 91 cases, give a mortality rate of only 21.4 per cent for cases operated upon within the first 12 hours. In those who had surgery after 24 hours, the mortality rate was 61.6 per cent. This re-emphasizes the necessity for immediate surgery.

SUMMARY

Five cases of omphalocele are reported. Of the 5, 1 was born dead, another lived but a few minutes, and the remaining 3 were treated surgically. Of these 3, 1 died 10 hours following surgery and 2 survived. One of these is known to be in good health at the age of 2½ years.

The embryology of omphalocele is discussed.

Associated anomalies are commonly found.

Surgical treatment within 6 hours of birth is advisable and offers, with occasional exceptions, the only chance of survival. The prognosis depends upon the time elapsing before surgery, the diameter of the defect in the abdominal wall, the size of the hernia, and the nature of the contents of the sac. Newborn infants tolerate anesthesia and heavy surgery surprisingly well.

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AVULSION OF SCROTUM AND SKIN OF PENIS

Technique of Delayed and Immediate Repair

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AVULSION of penile and scrotal tissue has occurred in 3 cases. In each instance it was the result of loose clothing being caught in rapidly moving machinery. In the first case (Fig. 1) a hanging overall strap became engaged in a tractor belt, thus pulling the man into the machinery, stripping his overalls from him, and catching the loose skin of the scrotum and penis in the twisting overalls. The second case was the result of a power-driven drill-bit catching the overalls and twisting them and the skin of the genitalia. In the third and most recent case, the workman was astraddle a power-driven shaft, from which was projecting a set-screw. The rotary motion of the shaft engaged the overalls, which in turn caught the penile and scrotal tissues (Fig. 2). In 2 of these cases, the scrotum, a portion of the pubic skin, and most of the penile skin was avulsed. In one of these, one testicle was torn away. In the third, approximately two-thirds of the scrotum was taken along with the penile skin.

Such defects of the genitalia are rather rare. Brown (2) has reported 2 cases with loss of the skin of the shaft of the penis following circumcision, a third, the result of granuloma inguinale, and a fourth the result of a gunshot wound. Owens has reviewed the literature and reported repair in 2 cases. It is obvious that this type of deformity can present an acute problem to the patient aside from the functional aspect. It may also present a difficult problem of repair to the doctor.

Selection of tissue for repair. Pedicle scrotal flaps supply the most desirable tissue for covering penile defects because of the elasticity of the transplanted skin (1). This is especially true when there has been damage to the cavernosum with deep scarring and contraction. In many of these cases scrotal tissue is not available since it also has been lost. Even under ideal circumstances, the scrotal tissue may be inadequate in amount for complete coverage of the penis. A third point to be considered is that a wound of the penis which has contracted may undergo further contraction during the period of attachment of the penis to the scrotal flap.

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Pedicle flaps from other portions of the body are too thick and lack the desired elasticity.

Free skin grafts. Thick, split skin grafts seem to answer most nearly the needs in the average case. If possible, it is oftentimes desirable to use a combination of scrotal flap and free skin graft, especially to prevent possible scar constriction about the base of the penis. The difficulty of take in this area makes the free full thickness graft less desirable. The disadvantages of the free skin graft are that the skin is not as expansile as is normal penile skin and that the grafts tend to contract for a period after their application. Both of these difficulties may largely be overcome by the transplantation of an adequate amount of skin. This is done by making the wound the maximum size at the time of application and by supplementing the graft if necessary at a second operation.

Preoperative preparation of the ulcerated wound. This is the same as that which has previously been described for ulcerations of other types (3, 4). All surrounding hair should be kept shaved, the area should be frequently cleansed by the use of soap and water; sulfanilamide or sulfathiazole powder should be dusted on the surfaces one or more times daily. The patient sits in a saline bath for several hours daily if possible. In between soaks, sterile, fine-mesh gauze is applied to the wound, and over this is applied a firm, bulky, normal saline dressing, held in place with a suspensory or athletic supporter. This dressing is changed frequently. When the granulations have become compact and uniformly red, and there is a minimum of discharge on the dressings, and the appearance of the wound has ceased to improve, it is ready for grafting.

Operative technique. Granulation tissue is trimmed away with a sharp knife, carefully dissecting away the deeper scar, until the penis is completely elongated and freed from the contraction which has resulted from partial healing. All bleeding points are carefully ligated with finest available silk. If there is any of the normal skin left on the penis, either about its base or the glans, this skin is retracted. A collar of skin about the base of the penis can be sutured back as a roll at its junction with the abdominal wlal. A collar of skin about

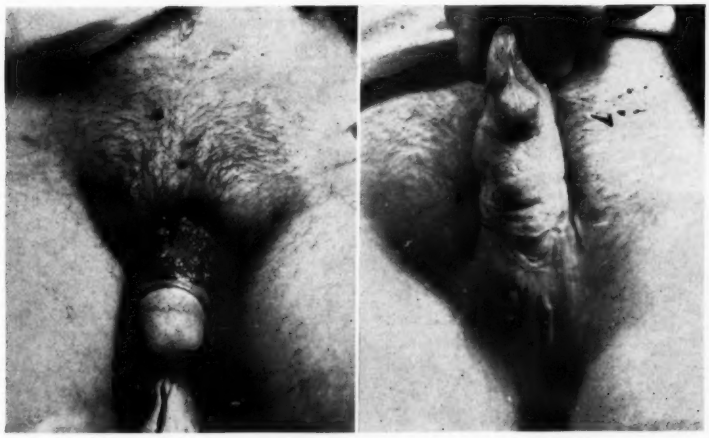
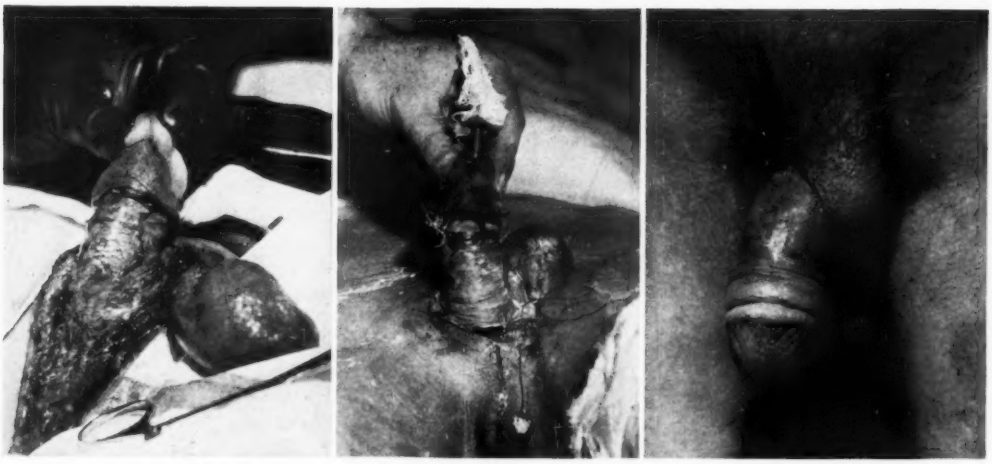


Fig. 1. a, left, Granulating wound and absence of scrotum as result of avulsion of these tissues. Both testicles were transplanted into the inguinal canals by the surgeon giving them emergency treatment. There is considerable shortening of the penis. b, Result 3 months after split skin grafting. There is still some shortening of the penis. The graft is becoming soft and flexible. A second operation was done subsequent to this, a circular incision being made about the base of the penis, the penis being elongated by dissection of scar, and a second graft being applied to this area. Photograph subsequent to second operation was not obtained but patient had functional result.

its attachment to the glans can be drawn toward the tip of the penis in a similar manner. This makes available a larger wound for grafting and consequently aids in getting the desired excess of skin on the wound. If a perineal or scrotal ulceration is present, it is similarly prepared by excision of granulations and underlying scar.

A split thickness skin graft, approximately two-thirds the thickness of the skin, is taken, if possible, getting one piece large enough to cover the entire wound. A catheter is inserted into the bladder, and the penis is held completely extended. The graft is draped over the wound, and sutured accurately to the wound borders, proximally and distally, with interrupted sutures. Where the borders of the graft meet, they are sutured together with a running silk suture, slightly overlapping the graft borders to insure complete coverage of the defect. The graft is applied under normal skin tension. The interrupted sutures at the proximal and distal borders of the graft are left long. Quilting stitches may be applied, longitudinally, up and down the graft, but these must not go in a circular manner about the penis, for fear of a tourniquet effect if erection occurs (Fig. 3a). If the graft extends down in the perineum or on to the scrotum, it is sutured here with long interrupted silk sutures. The graft is dressed by dusting it with sulfanilamide powder and then covering it with fine-mesh gauze impregnated with some bland ointment. A large bulk of cotton machinist's waste is built up around the defect. This is held in place by tying the interrupted sutures at the proximal junction of the graft and skin to those at the distal junction over the pad of waste. The sutures on the lateral borders of the perineal defect are tied together over the pad of machinist's waste (Fig. 3b). This fixation of the dressing with sutures preserves the elongated position of the penis, and serves as a splint to the wound. It keeps the tension on the applied graft uniform. Over this dressing is applied a very bulky mass of gauze and the entire dressing is firmly bandaged in place around the upper thighs and abdomen.

Postoperative care. The first wound dressing is done on the 4th or 5th postoperative day. At this time most of the sutures are removed, the graft is cleaned gently with boric solution and is powdered with sulfanilamide powder. A dressing as nearly like the original as possible is reapplied. After the 7th or 8th postoperative day, the catheter is removed, and a similar but less bulky dressing is applied, and held in place with an athletic supporter. Split thickness grafts undergo a period of contraction during the first 2 months. Following this, they begin to soften and relax. In 1 of the 3 cases described, a second operation was



a b c

Fig. 2. a, Photograph of wound taken at time of operation, 18 hours after accident. There has been an avulsion of the right testicle, all of the scrotum, most of the penile skin, and a portion of the skin of the pubic region. b, Photograph taken 5 days later at time of first dressing of the graft. The graft-covered testicle is shown just outside the inguinal ring. There was almost complete take of the graft. c, Result 7 weeks after operation. Grafted skin is becoming soft and pliable and seems adequate in amount. Patient did not desire transplantation of testicle into inguinal canal.

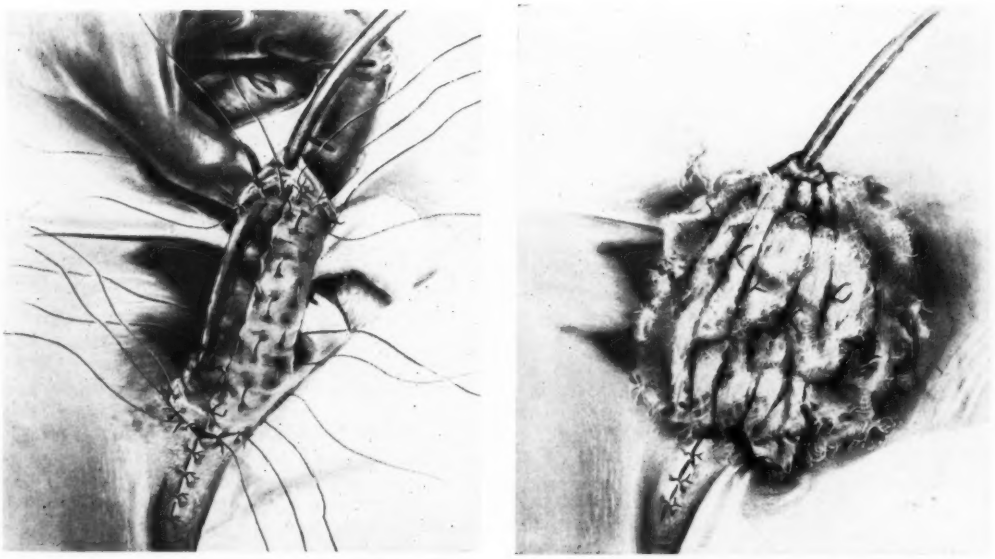


Fig. 3. a, left, Diagrammatic presentation of method of applying split thickness skin graft as it was done in case illustrated in Figure 2. The testicle is omitted from the drawing for simplification. b, Illustrating fixation of dressing. Adjacent to the graft has been applied a layer of fine-mesh vaseline gauze. On top of this is built up a mass of machinist's waste, and the sutures at the proximal junction of the penis and skin graft have been tied to those at the distal junction over the waste in such a manner as to maintain elongation of the penis and give the maximum length of wound to receive the skin graft. Over this will be applied a very heavy and bulky dressing which is firmly bandaged in place about the abdomen and thighs.

done, supplementing the original graft to give additional length to the penis (Fig. 1). In all cases, the skin has eventually become soft, reasonably loose, and of a normal sensation.

Repair of defect immediately after injury. In 1 case, the patient was received 18 hours after the accident (Fig. 2).

His attending physician had first seen the man a few moments after the injury. Bleeding was slight. He had shaved the surrounding area, removed gross contamination, freely covered the wound with sulfanilamide powder, and as quickly as possible transported him to Barnes Hospital. This 53 year old man was suffering little pain, and stated that the pain had never been severe. He was having no difficulty voiding. At examination it was found that a small collar of skin remained about the glans. All other penile skin, including a portion of pubic skin, and the entire scrotum were missing. The right testicle and cord were absent. The left testicle was present, completely exposed. It was somewhat edematous and swollen. Much hair was imbedded in the wound. There was no cellulitis. The area was gently washed with sterile soap and gauze. The wound was irrigated copiously with large amounts of saline, and all foreign material was picked out of the wound. Following this, the perineal wound was sutured in the midline, as far as it could be closed without tension. The testicle was sutured in the external inguinal ring with interrupted sutures, much after the fashion of a cork in a bottle. Because of the duration of the wound and the contamination, it was not considered desirable to open up further tissue as would have been necessary to implant this testicle in the inguinal canal. A large single split graft was then applied to the penis, the open portion of the perineal wound, and over the exposed part of the testicle. This was dressed as previously described. There was almost complete take of the graft. The patient had very little pain or local difficulty at any time. On the 12th postoperative day, patient had a pulmonary embolus from which he recovered. A second such accident occurred on the 25th postoperative day. These were presumably from the traumatized spermatic veins. Never at any time did he have any infection about the wound. At the time of the last observation, patient was completely healed and the graft was soft and flexible enough to permit normal function. The skin graft covered testicle was in a position as shown in Figure 2c. It was proposed to transplant this higher in the inguinal canal to place it in a less exposed position, but the patient did not consider this necessary.

CONCLUSION

These cases are presented first with the idea of expressing the desirability of primary repair rather than subjecting the patient to the prolonged discomfort coincidental with secondary repair. In addition, it is felt that skin grafting of properly prepared open wounds resulting from avulsed tissue is practical and should be considered even though a number of hours have elapsed since the injury. In a number of cases heretofore, we have made use of the principle of grafting a freshly created traumatic wound with the idea of getting quick healing. This may be especially important on the eyelids. However, this is our first case as old as 18 hours that has been so treated. Emphasis should be placed on the proper cleansing of the wound, regard for not introducing further contamination (5), and the use of sulfanilamide crystals.

In none of the 3 cases was restoration of the scrotum attempted. It is obvious that under some circumstances such a reconstruction might be considered essential. If this is contemplated, the testicles should be planted under the skin and subcutaneous tissue of the upper, inner thighs at the time of the initial repair. After the defect of the penis has been adequately repaired and healed, each testicle and its cord would be dissected free from the thigh, carrying with it the overlying skin and fat. The tissue from the right and left thighs would then be sutured together in the midline, the testicles with their overlying skin and fat being joined to make the two halves of the reconstructed scrotum. This would occupy approximately the normal position and probably maintain nearly the optimum temperature of these organs. This reconstructed scrotum would not be contractile. The two donor sites on the inner surface of the thigh would be covered with split thickness skin grafts.

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EDITORIALS

SURGERY
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SEPTEMBER, 1943

INFECTIONS OF THE URINARY TRACT

WHEN one peruses the voluminous literature on infection of the urinary tract which has appeared in the past decade, one is impressed first of all by the tremendous progress which has been made in the treatment of this disease. To begin with, this advancement was largely stimulated by the work of Helmholz and Clark on the bacteriological aspects of infections of the urinary tract. Their studies have contributed much to present day knowledge, but only too frequently are their methods thrown aside and treatment carried out empirically.

With the development of the numerous sulfonamide compounds and their known efficacy in combating infections of the urinary tract, many physicians prescribe these drugs without a sufficient knowledge of the underlying bacteria in the given case, without knowing the true pathological changes and without proper respect for the various toxic manifestations which may develop in any case.

Complete bacteriological studies are not necessary in each case by any means. The expense to the patient is not justifiable. However, a simple gram-stain of the urinary sediment which is at the disposal of all surgeons will usually suffice and lead one to the proper management of the patient. Cultures are helpful but are not always necessary.

By the same token, one cannot expect every patient with an infection of the urinary tract to submit to a complete urological investigation. Many such patients may be cured of their illness with chemotherapy as their difficulty is superficial. However, if after one or two courses of medication, the desired results are not obtained, these patients are entitled to a detailed urological investigation. It is well known that the percentage of cures in cases of infection of the urinary tract falls sharply when one passes from the uncomplicated to the complicated infection. Stone, tumor, obstruction, or chronic inflammatory changes in the kidneys definitely decrease the value of chemotherapy, and in many instances this is of no value until the coexisting or primary pathological lesion is removed.

When considering the drugs themselves, one should not lose sight of the value of mandelic acid. It should not be used in cases of impaired renal function as in such cases it is toxic to the kidney. Concerning the sulfonamide compounds, there is a very definite need for continued and close observation while the patient is taking the drug. Many compounds have been used and rightfully so, as some are more toxic in one case than in another, some more efficacious in one case than in another.

If everything possible is to be secured from chemotherapy in infections of the urinary

tract, a close check on each individual patient must be kept. Doses should not be excessive. Helmholz has repeatedly demonstrated experimentally that small concentrations of any of these drugs will sterilize the urine. This has been borne out clinically. Seldom, if ever, will increased doses do more than will the usual small dose.

These remarks are a renewal of the plea for the proper management of urinary tract infections. There is no more grateful patient than one who suffers from vesical distress and is relieved of the irritating symptoms.

EDWARD N. COOK.

MODERN ANESTHESIOLOGY AND THE ANESTHETIST

THE development of modern anesthesiology and the training of anesthetists has always received my ardent support. It might be well to state, however, that any convictions I may have are the result of gratifying, convincing personal experiences and are not the result of an enthusiasm for a hobby or an interest in a personal program. The fact that many surgeons continue to be satisfied with nonmodern anesthesia and anesthetists, and the fact that these surgeons remain unaware of how much easier their work could be made to say nothing of the increased safety afforded their patients by more modern methods, prompt this statement.

Since the day when the Lahey clinic was started the great opportunity to advance the standards of surgery by improving the methods of administering anesthetics and the training of anesthetists has been ever before me. The work of the anesthetist was formerly largely limited to the administration of ether, and anesthesiology was a neglected field. The expansion of surgical boundaries was thus limited by the use of a few anesthetic agents and methods of administration by a few gentle natured, underpaid physicians.

Many anesthetists had gravitated into the field because it provided a refuge from competition in other fields of medical endeavor and a moderate but uncontested source of livelihood. This psychic haven of professional refuge was made still more attractive to these unaggressive personalities by the fact that the surgeon of that period usurped the complete responsibility for the type of anesthesia to be used, its depth and course, the patient's condition, and any complications which the patient might suffer during or after the operation. Add to this the fact that the patient usually saw the anesthetist either briefly the night preceding the operation, or for the first time when anesthesia was about to be induced, and almost never after operation, and we are able to establish the base line from which has been evolved the present superstructure of the modern methods of administering anesthetics and of training anesthetists. Unfortunately, in many institutions anesthesiology is still at or near this base line level.

In order to emphasize the nature of modern anesthesiology as well as the accomplishments of a modern anesthetist, it might be well to mention the ideals to be attained in the training of an anesthetist.

He should have a fundamental knowledge of pharmacology and physiology; he should be able to induce expertly all types of anesthesia; he should, of course, be familiar with the newer agents and the methods of their administration, as, for instance, the induction of fractional (continuous) spinal anesthesia and anesthesia by means of the intravenous injection of the barbiturates. However, he should not neglect the older but still valuable agents and methods; it is still very important that the anesthetist be expert in inducing ether anesthesia and that he be able to recog-

nize in a given case the value as well as the limitations of the use of nitrous oxide gas anesthesia, particularly with reference to the immediate and remote effects of anoxia. He should be able and be permitted to exercise judgment in the selection of the anesthetic agent and method he considers best adapted to the patient and the proposed operation.

He should be able to administer cyclopropane, but he should also be cognizant of the possible dangers associated with the use of this agent in certain types of patients, particularly with reference to the possibility of producing cardiac irregularity and even ventricular fibrillation in the presence of a damaged myocardium. He should be familiar with, and constantly aware of, the explosion hazard and should fully recognize that this hazard is not limited to ethylene and cyclopropane, but is also present when nitrous oxide, oxygen and ether, or oxygen and ether combination, are used. He should be aware not only of the various explosive anesthetic mixtures but should be acutely aware of the importance of the static spark as the causative agent in so many explosions. Furthermore, he should be familiar with the recognized safety methods that have been developed as protection against explosion.

He should be familiar with the use of a direct laryngoscope, either for the passing of an endotracheal catheter or the inspection of the larynx and vocal cords. In fact, no matter how much the trachea is deviated or narrowed, he should be capable of introducing an endotracheal catheter either by the direct route or by one of the so called "blind" methods of intubation.

He should recognize the importance of keeping the tracheobronchial tree free of secretions and other fluid, and should be prepared and able to remove these secretions before operation, during operation, and after operation; in other words he should be familiar with the technique of bronchoscopy, and should be able to recognize when this procedure is indicated.

He should be capable of maintaining constant, positive pressure anesthesia when indicated and of maintaining artificial respiration when for any reason, such as an overdose of an anesthetic agent or the spinal anesthesia has inadvertently gone too high, the patient is unable to maintain his own respiration.

His knowledge of spinal anesthesia should not be limited to the use of procaine crystals, but he should be familiar with the various pontocaine and nupercaine techniques, as well as with fractional (continuous) spinal anesthesia. He should be capable of inducing all types of regional anesthesia as well as carrying out all the various nerve blocks for diagnostic and therapeutic purposes.

Gas therapy quite logically falls within the scope of anesthesiology. The well trained anesthetist should be capable of supervising all types of gas therapy, particularly administration of 100 per cent oxygen and helium.

This editorial is based upon the teaching program employed in this clinic for the instruction of its fellows in anesthesiology. Similar instruction is also available in many other institutions. It can be said, therefore, that the refinements in producing anesthesia here mentioned are not merely ideals but actual accomplishments and that as such they are attracting extremely capable and enthusiastic young men to this field. The improvements in the practice of anesthesiology have opened up another relatively new field of medical endeavor which has not only widened the range of surgical undertakings but has also made surgical operations less of a physical and emotional ordeal for the patient and also for the surgeon. This statement is truly borne out by our experience. FRANK H. LAHEY.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE authoritative modern monograph on the physiology of external pancreas secretion and diseases of the pancreas, *Pancreatic Function and Pancreatic Diseases*[1] by Henrik O. Lagerlöf, is a painstakingly accurate review of all prior work on the subject supplemented by extensive investigations by the author and his associates in Berglund's clinic in St. Erik's Hospital in Stockholm. It was translated into English by Helen D. Frey and contains a commendatory foreword by Dr. Joseph H. Pratt of Boston, a recognized clinical authority on the subject.

The monograph is divided into five sections. The first concerns the physiology of pancreatic secretion exclusively. Complete reviews of all other work on the subject include those major contributions of Claude Bernard, Pavlov, Bayliss and Starling, Hammarsten, Babkin, and Ivy. The author's experimental work with Ågren and others is described in detail, including methods and results. By means of secretin, the secretion of pancreatic juice and analysis of its constituents establishes normal human function as clearly as is possible at the present time. Lagerlöf's studies are unique in that his methods permit the collection of human pancreatic secretion uncontaminated by gastric juice or saliva, and uninfluenced by passage of acid chyme into the duodenum. A double tube makes this possible, one aspirating pancreatic juice from the jejunum and the other simultaneously aspirating all gastric contents from the higher level. The English account of reports of these experiments and their correlation with other pertinent data makes this volume indispensable to all physiologists.

Of even greater value is the review of pancreatic diseases and their study by improved methods of pancreatic juice analysis. The last four sections of the monograph describe pancreatic diseases, their differential diagnosis, their study by means of the secretin test and enzyme analysis, with illuminating case reports and appendices. The bibliography of 358 references to published data on the subjects of the monograph indicates the thoroughness of the author's coverage.

As expressed by Dr. Pratt in the foreword, "The work reported by Lagerlöf has lifted pancreatic analysis to the level gastric analysis has occupied for many years." Unquestionably this monograph is the most complete and authoritative review of pancreatic external secretion function and disease in existence. It should be studied and its clinical methods employed by every gastroenterologist.

ARTHUR R. COLWELL.

AN excellent monograph by Charles C. Higgins[2] on the subject of urinary lithiasis has recently been published. In a brief but comprehensive manner the history, etiology, symptomatology, and treatment are so included as to make interesting as well as instructive reading. The author has long been interested in the etiology of renal calculi and has previously made valuable contributions along this line. These together with the more pertinent work of others have been completely, but simply, arranged so that the summary is clearly understandable.

Methods for the qualitative analysis of renal calculi are presented. The dietary methods for attempting the dissolution of renal calculi, as well as a preventive for recurrence after spontaneous passage or surgical removal, are discussed in great detail. The author presents many carefully formulated diets to be advocated in these patients. All diets are based upon complete and satisfactory analyses of the chemical components of the calculi, recovered or removed, from each patient.

VINCENT J. O'CONOR.

THE small volume entitled *Burns, Shock, Wound Healing and Vascular Injuries*[3] prepared under the auspices of the National Research Council is rich in authoritative and practical information. Its authors have done an outstanding piece of work for the medical officers in the armed services in making available to them in condensed and readable form up-to-date conceptions of burns, shock, and wound healing. Moreover, this book should be in the hands of every civilian physician who is concerned with these conditions.

The first section of the book deals with burns and was prepared by a committee headed by Roy D. McClure and including Conrad R. Lam, Henry N. Harkins, James Barrett Brown, and David P. Barr. The general treatment of the patient with a severe burn is dealt with in detail. The early local treatment of the burned area is thoughtfully considered, and a table is included giving the committee's choice of local treatment of the various burned regions of the body in accordance with the depth of the burn,

[1] PANCREATIC FUNCTION AND PANCREATIC DISEASE; STUDIED BY MEANS OF SECRETIN. By Henrik O. Lagerlöf, M.D. Translated by Helen D. Frey, with a foreword by Joseph H. Pratt, M.D. New York: The Macmillan Co., 1942.

[2] RENAL LITHIASIS. By Charles C. Higgins, M.D. Springfield, Ill.: Charles C. Thomas Co., 1943.

[3] MILITARY SURGICAL MANUALS. VOLUME 5. BURNS, SHOCK, WOUND HEALING AND VASCULAR INJURIES. Prepared under the Auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council. Philadelphia and London: W. B. Saunders Co., 1943.

the care of the granulating surfaces, the early plastic treatment of burns, and skin grafting for contractures following burns. There is a short but valuable chapter on burns in chemical warfare.

The section on shock has been prepared by a committee led by Alfred Blalock, chairman, and including Philip Bard, Norman E. Freeman, Frank C. Mann, Henry K. U. Beecher, Paul D. Lamson, D. B. Phemister, and Max M. Strumia. In this clear presentation may be found a satisfactory definition of shock and a full consideration of the criteria, pathology, and factors in the production of shock, and the prevention and treatment of shock, including an entire chapter devoted to fluid replacement therapy.

The section dealing with wound healing has been prepared by Allen O. Whipple and is a classic description of the subject. The section on vascular injuries has been prepared by a committee headed by John Homans and including Arthur W. Allen, Daniel C. Elkin, Geza de Takats and Walter G. Maddock. This very valuable section discusses the treatment of hemorrhage and the injuries to large arteries in general. The injuries of arteries in special locations are taken up individually. Diseases of the arteries and of the veins are succinctly presented. This section is beautifully illustrated by means of excellent line drawings.

This volume is a clearcut, brief summation by outstanding men of the really important knowledge of the various subjects. It can be recommended most highly. FREDERICK CHRISTOPHER.

THE eighth edition and the new text of *Diseases of the Nose, Throat and Ear*[1] by William and Howard Ballenger will creditably live up to the high standard set for it by the previous editions which have all been foremost in this field.

The book has been revised and practically rewritten; many things which have become obsolete have been eliminated and an abundance of new material has been added along with numerous illustrations in black and white and in color.

Dr. Brian T. King and Dr. J. D. Kelly have contributed a description of their surgical procedures for the relief of bilateral paralysis of the recurrent laryngeal nerves, and Dr. Alfred Lewy also has written an excellent chapter on physiology, functional tests, and inflammatory diseases of the labyrinth. A chapter on paralysis and neurosis of the larynx has been very well done by Dr. John J. Ballenger. Dr. Chevalier L. Jackson has revised the chapter on direct laryngoscopy, bronchoscopy, esophagoscopy and gastroscopy. The technique of each procedure is carefully described and illustrated with instructive pictures. The diagnosis, pathology, and treatment are discussed in each condition.

The chapter on gastroscopy gives a good description of the Schindler flexible gastroscope and its advantages in examining the interior of the stomach.

The Lempert fenestration operation for relief of deafness due to otosclerosis is fully described and with many illustrations showing the various steps in this procedure. Also the endaural mastoidectomy for the relief of chronic suppurative otitis media is described.

This book is written in an easily read style and covers in a comprehensive way the entire field of otolaryngology thus making it a most valuable text for the specialist, the general practitioner, and the student. LINN F. MCBRIDE.

THE second volume by Doctor Trueta[2] relating his experiences in war surgery has been published. His first volume was printed in Catalonia during the recent Spanish war. This second volume is a detailed description of the "five point program" necessary in the treatment of war wounds and fractures. The material was developed from his work in Spain and recently at the Wingfield-Morris Orthopaedic Hospital. The book contains 400 pages with 144 illustrations and is divided into two parts. Part I depicts the pre-Listerian and post-Listerian history of surgery and indicates that the greatest progress in general surgery has been developed during wars. In reading again of Joseph Lister's contribution we cannot help but be warned of the analogy between phenol and the sulfonamides, for with the development of the antiseptic technique the progress of surgery was hindered for a considerable time. Many surgeons came to think that the actual operative procedure was a matter of minor significance and that success depended entirely upon the use of carbolic acid. The author completes Part I with a detailed but easily read report on the treatment of wounds, shock, gas bacillus infections, and tetanus as related to war surgery. Part II is the meat of his thoughts in regard to the biological treatment of wounds in a five point program:

1. Prompt surgical treatment, i.e. within 6 hours.
2. Cleansing of the wound with soap. "I am personally so convinced of its value that I would be willing to use almost any variety of soap in preference to the best chemical antiseptic yet known."
3. Excision of the wound. (It is well to discard the word débridement which means incision.) It requires considerable experience to learn the technique of proper and adequate excision, which is probably the most important part of the five point program.
4. Provision for drainage. "The provision of adequate drainage, not only for the tissue fluids that must be evacuated but also for the extravasated blood which fills every small corner of the wound, demands a special technique. The absorbent capacity of gauze, however high, is not unlimited, and consequently after a while it will be unable to absorb any further discharge. If the discharge is not

[1] DISEASES OF THE NOSE, THROAT AND EAR; MEDICAL AND SURGICAL. By William Lincoln Ballenger, M.D., F.A.C.S., and Howard Charles Ballenger, M.D., F.A.C.S. 8th ed. Philadelphia: Lea & Febiger, 1943.

[2] THE PRINCIPLES AND PRACTICE OF WAR SURGERY; WITH REFERENCE TO THE BIOLOGICAL METHOD OF THE TREATMENT OF WAR WOUNDS AND FRACTURES. By J. Trueta, M.D., with introduction by Owen H. Wangensteen, M.D. St. Louis: The C. V. Mosby Co., 1943.

to be retained in the wound, the gauze must be supplemented by some other substance still more absorbent than itself. Here the plaster cast provides one of its many advantages, for good plaster of Paris is very absorbent. It is important that the plaster should be applied in direct contact with the gauze, and its quality must be good; some brands on the market have little or no absorbent capacity. In treating compound fractures by the methods I describe, a nonhydrated plaster of Paris of the type called 'alabaster' should be used, for this when set is highly absorbent."

5. Immobilization in a plaster of Paris cast. The author writes in detail of the application of the plaster cast giving the advantages and disadvantages of both the plaster bandage and pattern technique. He describes the treatment for all types of fractures.

He writes of his success with the Corachán technique of skin grafting, articular wounds, amputations, and burns.

This book is a comprehensive, well written, easily read review of the work of many surgeons and put into a well organized workable plan by the author. It is not all new material for, as Dr. Wangensteen who wrote the introduction points out, Frederic S. Dennis, a New York surgeon in 1884, reported 244 compound fractures treated with soap and water, excision, and plaster cast. Those of us in America who adhere to the teachings of Kanavel and Koch will read this book without too much adverse criticism.

A senior medical student, interne, general surgeon, orthopedic surgeon and especially any doctor entering the armed service of his country would be greatly benefited by reading this book.

JOHN M. HOWELL.

THE outstanding feature of the remarkable little book *Essentials of Proctology*[1] by Harry E. Bacon is its vast content of accurate and pertinent information, beginning actually on the inner side of the front cover with a useful index of symptoms and signs. The author is thoroughly versed in the literature of his field and keeps well abreast of what his confreres in proctology are doing. These facts coupled with the author's extensive teaching and clinical experience render him well qualified for the task of authorship on proctological subjects.

The volume offers excellent illustrations, done by a well recognized medical artist, and presents several differential diagnostic tables which should appeal to student and to practitioner alike.

Although the author mentions the etiological factor of cryptitis in anorectal inflammatory disease he omits any discussion of the rôle of anal glands, anal ducts and lymphatics in the pathogenesis of the common anorectal infections. This factor of "anal infection," brought forth by Herrmann some 60 years ago, is again receiving recognition.

Bacon describes anorectal abscesses in one chapter and anorectal fistulas in another. The reviewer subscribes to Buie's belief that abscess and fistula merit consideration in one and the same chapter, thus stressing, from the teaching standpoint, the fact that an anal abscess is merely a step in the pathogenesis of an anal fistula. An additional objection is raised to the use of the adjective "incomplete" pertaining to fistula. If a fistula (so called) is incomplete it is not a fistula; it is a sinus!

The author's presentation of venereal lymphogranuloma is indeed excellent, portraying in brief the results of the extensive study he has made of this entity. However, the author refers to a "difference in male and female lymph drainage" as responsible for different clinical manifestations in the two sexes. Actually the arrangement of the lymphatics is the same in homologous structures in the male and female. The difference in clinical manifestations of venereal lymphogranuloma in the two sexes lies in the different sites of the primary lesion, i.e. external genitalia in the male usually, and internal genitalia in the female (posterior vaginal wall, and/or cervix).

In his discussion of pilonidal cysts the author omits mention, under treatment, of the method of exteriorization (described by Buie). This procedure has proved of great value in military surgery—current reports of the success of primary closure notwithstanding.

The reviewer regrets the lack of illustration of, and the lack of detail regarding the surgical management of anomalous anorectal conditions. When the practitioner does have need for such information he needs it quickly. Few surgeons can boast of an extensive experience in this problem.

Especially for the benefit of the student it would have been well to mention the use of soap and water in the preoperative preparation of the skin. The value of this procedure has been clearly set forth by Koch and his associates.

This timely volume is indeed an invaluable contribution to proctological literature.

J. PEERMAN NESSELROD.

[1] ESSENTIALS OF PROCTOLOGY. By Harry E. Bacon, B.S., M.D., F.A.C.S., F.A.P.S. With an introduction by Curtice Rosser, B.A., M.D., F.A.C.S., F.A.P.S. Philadelphia, London, Montreal: J. B. Lippincott Co., 1943.

CORRESPONDENCE

CHEMICAL CONSIDERATIONS GOVERNING THE LOCAL CHEMOTHERAPY OF WOUND INFECTIONS

IT has been called to our attention that in the article entitled "Chemical Considerations Governing the Local Chemotherapy of Wound Infections," by the late Franz C. Schmelkes, in the July, 1943, issue, an error has been made in the use of the term "hydrogen ion concentration" and the symbol "*p*H." The first paragraph on page 72 should read:

"*Application of these findings in the local therapy of wounds and burns.* As has been shown, infected wounds are acid. Sulfonamides in general are much less active under acidic conditions and between *p*H 5 and 6 even the more active compounds, sulfathiazole and sulfadiazine, exhibit only a fraction of their maximum activity. The activity of sulfonamides can be increased by raising the *p*H, which increases their dissociation and apparently also increases the effectiveness of the molecular form. While the more active compounds, sulfathiazole and sulfadiazine, are largely dissociated at *p*H 7, the activity of sulfanilamide can be raised to that of sulfathiazole and sulfadiazine by raising the *p*H from slightly above the neutral point up to *p*H 9. Due to the much greater solubility of sulfanilamide, a local chemotherapeutic effect might be had at *p*H 9 that would exceed that of sulfathiazole and sulfadiazine."

The Editors.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A HANDBOOK OF MEDICAL LIBRARY PRACTICE; INCLUDING ANNOTATED BIBLIOGRAPHICAL GUIDES TO THE LITERATURE AND HISTORY OF THE MEDICAL AND ALLIED SCIENCES. Based on a Preliminary Manuscript by M. Irene Jones. Compiled by a Committee of the Medical Library Association. Edited by Janet Doe. Chicago: American Library Association, 1943.

PAIN MECHANISMS; A PHYSIOLOGIC INTERPRETATION OF CAUSALGIA AND ITS RELATED STATES. By W. K. Livingston, Lieutenant Commander, M.C., U.S.N.R. New York: The Macmillan Co., 1943.

DIAGNOSIS OF UTERINE CANCER BY THE VAGINAL SMEAR. By George N. Papanicolaou, M.D., Ph.D., and Herbert F. Traut, M.D. New York: The Commonwealth Fund, 1943.

PICTORIAL HANDBOOK OF FRACTURE TREATMENT. By Edward L. Compere, M.D., F.A.C.S., and Sam W. Banks, M.D. Chicago: The Year Book Publishers, Inc., 1943.

HUMAN GASTRIC FUNCTION; AN EXPERIMENTAL STUDY OF A MAN AND HIS STOMACH. By Stewart Wolf, M.D., Captain, M.C., A.U.S., and Harold G. Wolff, M.D. With a foreword by Walter B. Cannon, M.D. London, New York, and Toronto: Oxford University Press, 1943.

MANUAL OF FRACTURES; TREATMENT BY EXTERNAL SKELETAL FIXATION. By C. M. Shaar, M.D., F.A.C.S., Captain, Medical Corps, United States Navy, and Frank P. Kreuz, Jr., M.D., F.A.C.S., Lieutenant Commander, Medical Corps, United States Navy. Philadelphia and London: W. B. Saunders Co., 1943.

REHABILITATION OF THE WAR INJURED; A SYMPOSIUM. Edited by William Brown Doherty, M.D., and Dagobert D. Runes, Ph.D. New York: Philosophical Library, 1943.

MEDICAL MALPRACTICE. By Louis J. Regan, M.D., LL.B. St. Louis: The C. V. Mosby Co., 1943.

HISTORY OF SURGERY. By Richard A. Leonardo, M.D., Ch.M., F.I.C.S. New York: Froben Press, 1943.

PYE'S SURGICAL HANDICRAFT; A MANUAL OF SURGICAL MANIPULATIONS, MINOR SURGERY, AND OTHER MATTERS CONNECTED WITH THE WORK OF SURGICAL DRESSERS, HOUSE SURGEONS, AND PRACTITIONERS. Edited by Hamilton Bailey, F.R.C.S. (Eng.). 13th ed. Baltimore: The Williams & Wilkins Co., 1942.

SURGICAL CARE; A HANDBOOK OF PRE- AND POST-OPERATIVE TREATMENT. By R. W. Raven, F.R.C.S., Major, R.A.M.C. Baltimore: The Williams & Wilkins Co., 1942.

ANNUAL REPRINT OF THE REPORTS OF THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION FOR 1942; WITH THE COMMENTS THAT HAVE APPEARED IN THE JOURNAL. Chicago: American Medical Association, 1943.

NEW AND NONOFFICIAL REMEDIES, 1943; CONTAINING DESCRIPTIONS OF THE ARTICLES WHICH STAND ACCEPTED BY THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION ON JANUARY 1, 1943. Issued Under the Direction and Supervision of the Council on Pharmacy and Chemistry of the American Medical Association. Chicago: American Medical Association, 1943.

ROENTGENOGRAPHIC TECHNIQUE; A MANUAL FOR PHYSICIANS, STUDENTS AND TECHNICIANS. By Darmon Artelle Rhinehart, A.M., M.D., F.A.C.R. 3d ed. Philadelphia: Lea & Febiger, 1943.

THE GENEALOGY OF GYNAECOLOGY; HISTORY OF THE DEVELOPMENT OF GYNAECOLOGY THROUGHOUT THE AGES, 2000 B.C.–1800 A.D. By James V. Ricci, A.B., M.D. Philadelphia: The Blakiston Co., 1943.

MANAGEMENT OF THE COCOANUT GROVE BURNS AT THE MASSACHUSETTS GENERAL HOSPITAL. By Members of the Staff. Philadelphia, London, and Montreal: J. B. Lippincott Co., 1943.

AN ATLAS OF ANATOMY; IN TWO VOLUMES. By J. C. Boileau Grant, M.C., M.B., Ch.B., F.R.C.S. (Edin.). Vol. 1: UPPER LIMB, ABDOMEN, PERINEUM, PELVIS, AND LOWER LIMB. Baltimore: The Williams & Wilkins Co., 1943.

THESE MYSTERIOUS RAYS; A NONTECHNICAL DISCUSSION OF THE USES OF X RAYS AND RADIUM, CHIEFLY IN MEDICINE. By Alan L. Hart, M.D., M.Sc. (Med.). New York and London: Harper & Brothers, 1943.